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OBSERVED & REPORTED DRIVER BEHAVIOUR AT JUNCTIONS: IMPLICATIONS FOR DRIVER TRAINING (VOLUME 1)

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ABSTRACT

Over half of the accidents on British roads occur at junctions and it was the primary goal of this research to develop an increased understanding of the underlying factors behind these accidents. The vast majority of all road accidents are attributable to human error and the research investigated junction negotiation with respect to drivers' perceptions of the social and environmental components of driving.

The first part of the research, an observation study, gathered basic information about actual driver behaviour at junctions. The progress of over 3600 vehicles at four junctions of differing styles was recorded and analysed with the aid of a timebase video facility. It was found that approximately 7% of all drivers were involved in some form of near-miss for which evasive action was necessary. In addition to basic descriptive information, inferential statistical techniques were used to identify factors contributing to near-miss incidents in addition to signalling, tracking and approach speed behaviours. The information derived from this first study was used, in conjunction with that obtained from group discussions, to develop a questionnaire.

Using a postal distribution technique, the questionnaire was distributed to a random sample of British full driving licence obtained from the records of the Driver and Vehicle Licensing Authority. An additional sample was obtained from the Thames Valley Police accident records at Milton Keynes to ensure that a suitably-sized accident-involved sample was available for analysis.

The various sections of the questionnaire were designed to reflect different aspects of driving at junctions. In addition, respondents were asked to provide details of the most recent accident, if any, which they had been involved in. Just over half of the 740 respondents to the questionnaire reported such accidents, and the information provided was used to establish factors implicated in accident-involvement, and particularly accident culpability, at junctions.

In addition to sex and exposure factors, it was found that self-descriptive metavariables were the most effective at predicting aspects of involvement in accidents at junctions. In particular, those deemed to be accident-liable were more likely to describe themselves as self-centred and ill-mannered. Other metavariables, particularly those recording the subjective riskiness of various manoeuvres, were also found to be useful discriminators between various sub-groups of accident-involved drivers.

Finally, the differences in responses made by drivers who had been trained by a variety of methods, or combination of methods, were investigated. It was discovered that those drivers initially trained by a qualified instructor were more likely to respond in similar ways to accident-involved drivers. In contrast, those who had taken some form of advanced tuition were more likely to report more considerate, attentive traits.

Several suggestions for further research were made, particularly recommending the adoption of a longitudinal research design to enable causal relationships between accident-involvement and responses to questionnaire items to be determined.

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"...you could die from the danger..."

(Zappa, F. 'The Dangerous Kitchen', 1981)

"What the catepillar calls the end of the world,
the master calls a butterfly."

(Richard Bach, 1977)

"It's the end of the world as we know it ...
...and I feel fine."

(Stipe, M., 1987)

CONTENTS

VOLUME 1

PAGE

PAGE

PAGE

CHAPTER 8: RESULTS OF STUDY 2

PAGE

VOLUME 2

APPENDICES

LIST OF FIGURES

Figure: PAGE

PAGE

CHAPTER 1 :

LITERATURE REVIEW

1.0: OVERVIEW

Knapper and Cropley (1980) point out that, when considered on a yearly basis, road traffic accidents have been responsible for more casualties than many wars. This rather frightening concept ties in with a view expounded by Stonex, who suggested that the automotive system may be considered as:

"...precisely that which we would have built if our objective had been to kill as many people as possible." (Stonex, 1965, cited by Michon, 1980, p. 400).

Although this may appear to be slightly melodramatic, it is clear that there is a considerable problem within the road system today, and that research must be carried out to investigate ways in which the problem may be alleviated. This chapter takes the form of a review focusing upon many of the issues relevant to road safety research before outlining the direction for the present study.

The first section (1.1) looks at the extent of the problem by outlining the number of users on the roads at present and the number, severity and location of accidents in recent years. This is followed by a brief discussion of some of the general approaches that have previously been adopted by researchers in the investigation of road traffic accidents. As well as discussing the use of accident data to investigate the accidents, Section 1.2 also highlights the adoption of multidisciplinary approaches in addition to a brief review of behavioural approaches. Once a problem has been identified, it is clear that some form of intervention process should be adopted to alleviate that problem and Section 1.3 outlines the three main alternatives available to road safety researchers: enforcement, engineering and education. The education approach is probably the most complicated alternative, having many components, and the following section (1.4) assesses the current methods of driver training and the role of such programmes in the training and re-training of drivers.

A relatively recent development in the field of driver behaviour research is the use of error models to explain the mistakes made by drivers that result in accidents, and Section 1.5 reviews several of these theoretical approaches. There is little empirical evidence to support (or contradict) these theories, but cognitive frameworks have been used to try and explain driver behaviour for some time. Section 1.6 outlines many of the major approaches that have adopted cognitive and information processing principles, including brief sections on the study and assessment of risk and the use of decision theory as a basis for driving models.

The models described in Section 1.6 were found to have extremely similar core concepts, being concerned with drivers' internal representations of the 'driving world'. Therefore, the following section (1.7) was devoted to the discussion of this concept, labelled 'schemata', including details of the origins and uses of this idea prior to its' application to the study of drivers. Additionally, models containing the concept of schemata, and their relevance to the study of driver behaviour, are discussed. Finally, Section 1.8 summarises the main findings from the literature review as well as outlining the direction for the current research.

1.1: ROAD ACCIDENTS IN GREAT BRITAIN

1.1.1 General Road User Statistics

There are currently somewhere in the region of 24 million vehicles in use on the roads in Britain today, a figure that is constantly increasing. Statistics issued by the British Road Federation (1990) reveal that, when measured in vehicle kilometres covered, the amount of traffic on British roads has increased by almost 28% since 1980. Projected figures for the year 2015 suggest that there will be between 22.8 and 25.4 million cars alone on the roads, suggesting an overall figure of well over 30 million vehicles.

Table 1.1 (below) shows the number of vehicles of each major classification registered with the Driving and Vehicle Licensing Authority (DVLA) in 1989, along with similar figures for 1960, 1970 and 1980. It should be noted that the figures for 1960 and 1970 are not directly comparable with the more recent figures as the earlier figures are not derived from the same source and include some unlicensed vehicles. The British Road Federation estimate that the number of unlicensed vehicles may be in the region of one million (1984 figures). The 'Other' category in Table 1.1 includes vehicles such as agricultural tractors, tricycles, pedestrian controlled vehicles, show haulage, crown and exempt vehicles.

Table 1.1: Vehicles In Use In Great Britain Since 1960

Vehicles In Use (thousands)

Year	Private Cars	Motor Cycles	Public Transport Vehicles	Light Goods Vehicles	Heavy Goods Vehicles	Others	TOTAL
1960	5717	1796	93	565	641	627	9439
1970	11328	1048	103	1120	683	668	14950
1980	14772	1372	110	1461	575	910	19210
1989	19266	875	122	2009	614	1272	24158

Source: British Road Federation - Basic Road Statistics 1990.

Although the number of registered motorcycles has decreased quite considerably in the last decade, the overall figures for most other vehicle classes show a sizeable increase. In fact, the numbers of vehicles registered increased by 3.7% in the twelve months from 1988 to 1989.

1.1.2 Accident Statistics

Virtually no form of human activity is carried out with a zero error rate and driving is clearly no exception. With such large numbers of vehicles on the roads, all of them in almost constant interactions with other road users, it seems almost inevitable that a high number of accidents will result. Table 1.2 (below) shows the number and severity of all casualties involved in reported road accidents (divided into five categories of road users) for four separate years: 1965, 1970, 1980 and 1989.

Table 1.2: Road Accident Casualties for 1989 and in Relation to Previous Years

	Pedestrians		Pedal Cyclists		Motor-cyclists and Passengers		Car Drivers and Passengers		Other Road Users		TOTAL			Total Number of Casualties
Year	Fatal	Injury	Fatal	Injury	Fatal	Injury	Fatal	Injury	Fatal	Injury	Fatal	Serious Injury	Slight Injury	
1965	3105	81962	543	34429	1244	82170	2479	33743[1]	581	9510	7952	97865	292120	397937
1970	2925	82445	373	22733	761	48886	2877	159663	563	42142	7499	93499	262370	363368
1980	1941	61358	302	24486	1163	69675	2278	141239	326	25832	6010	79390	243200	328600
1989	1736	55844	227	25311	670	42166	2142	168563	236	23604	5052	63491	253762	322305

1 Includes serious casualties only.

Source: British Road Federation - Basic Road Statistics 1990.

The table reveals that there has been a gradual overall reduction in the number of casualties, with the decrease in fatalities (36.5% from the 1965 total) particularly encouraging. The total number of accidents has also decreased, but not quite as rapidly as the injury figures. This may, at least partly, be a consequence of the implementation of the seat-belt regulation laws in 1983, although it can be seen that the trend was already towards a reduction in injuries by that time. These figures are particularly encouraging when one considers the increase in the number of vehicles outlined in the previous section, although with over 300,000 people involved in road accidents in 1989 (and 5,052 dying as a result), it can be seen that there is plenty of scope for improvement.

1.1.3 Locations of Accidents

The previous section briefly outlined the extent of the road safety problem, and it is argued that it would now be useful to delve further into the sources of those accidents. Table 1.3 (over) shows the types of road locations at which the injury accidents for 1989 occurred, distinguishing between built-up and non-built-up areas and also between the three categories of injury severity. It should be noted that, in the following table, an accident was classed as a junction accident if it occurred within twenty metres of a junction.

Table 1.3: Injury Accidents by Junction Type for 1989

Junction Type:	Round-about	T/Staggered Junction	Y-Junction	Cross-roads	Multiple Junction	Private Drive/ Entrance	Other Junctions	All Junctions	Non-Junction Accidents
Built-up Roads:									
Fatal	42	901	38	267	26	54	43	1371	1027
Serious	1303	14121	638	4739	475	1423	661	23360	13188
All Severities	10489	76141	3604	27861	2983	8165	4141	133384	60290
Non-Built-up Roads:									
Fatal	19	314	84	117	6	86	45	671	1838
Serious	462	2483	598	915	71	814	220	5563	11155
All Severities	3458	10295	2627	3509	287	3321	996	24493	42553
TOTAL:									
Fatal	61	1215	122	384	32	140	88	2042	2865
Serious	1765	16604	1236	5654	546	2237	881	28923	24346
All Severities	13952	86446	6233	31371	3270	11489	5137	157898	102861

Source: Department of Transport - Road Accidents, Great Britain 1989 (1990).

Table 1.3 reveals that, when all accident severity categories are considered, more accidents occurred at junctions (59.2%) than at other road sections, although it is notable that the latter location-type accounted for a higher proportion of fatal accidents (58.3%) than junctions. In built-up areas, there were approximately twice as many junction accidents as non-junction accidents, with fatalities at the former outnumbering those at the latter by about a third. However, in non-built-up areas, the situation is reversed with over twice as many accidents occurring away from junctions as at them, increasing to three times for purely fatal accidents.

The table also clearly shows that T (or staggered) junctions are by far the most common junction type at which injury accidents occur, particularly in built-up areas. However, the figures do not account for the prevalence of each junction type, and common driving experience indicates that there are considerably more examples of this type of junction than any other. Unfortunately, without details of the quantity of each type of location, direct comparisons can not be made.

1.1.4 The Use of Junctions in the Road Network

The previous section highlighted junctions as a major general type of location for road accidents, particularly in built-up areas and when injury-only accidents are considered. Prior to discussing methods by which junctions may best be studied, it is felt that a brief outline of the use of junctions in the road environment is warranted. Given the extent and necessary level of complexity of the road network, it is clear that intersections between two or more roads must form an essential part of that road network. The main problems lie in the selection of the type of junction used and the method of controlling vehicles' rights of way at the junction. Polus (1985) identifies four major alternatives available in the controlling of priorities at junctions: leaving the intersection uncontrolled; placing a 'Give Way' (or Yield) sign on the minor road; placing a 'Stop' sign on the minor road; and finally using 'Stop' signs on both the major and minor roads.

The style of junction chosen is largely dependent on the number of roads meeting at the intersection, but the method of control is open to rather more debate. For example, some researchers (eg. Upchurch, 1983, cited by Polus, op. cit.) feel that 'Stop' signs are over-used and are too restrictive in many circumstances, the use of 'Give Way' signs being more economical in terms of aiding traffic flow. Indeed, a study by Polus (op. cit.) revealed that increasing the level of control at an intersection (ie. by employing 'Stop' signs) led to an increase in the number of vehicle accidents with an accompanying decrease in the number of pedestrian accidents. In reply, however, Frith and Derby (1987) found no evidence to support Polus and in fact found that 'Stop' signs had a 'favourable effect' on accident rates, although it should be noted that their findings were not statistically significant.

Roundabouts are a form of junction that have often been used in attempts to reduce accidents at particular 'blackspots'. A study conducted by the Transport and Road Research Laboratory in 1975 assessed the effect of the introduction of offside priority (ie. where drivers must 'give way' to vehicles to the right) roundabouts at 78 locations around Britain and found that the total number of accidents fell by 31%. A follow-up study by Lalani (1975) found that accident rates at 38 locations in the Greater London region fell by 39% after the junctions were converted to roundabouts. Mini-roundabouts have also been found to reduce the number of accidents at previously uncontrolled junctions. For example, Sabey (1976) reported that a 40% reduction was observed after the introduction of offside priority mini-roundabouts.

1.1.5 Accident Causation Factors

Road accidents may be attributable to a variety of causal factors such as mechanical defects, poor road design and adverse weather conditions. However, the majority of accidents cannot be reduced to a single causal factor and the interaction effects of such factors should be considered. The factor that appears to be most implicated in accident causation is human error. A 1975 TRRL report by Sabey and Staughton concluded that human error was the sole causal factor in 65% of all accidents, and a major contributor to 95%. As Thillainayagam puts it:

"Ultimately, everything goes back to the driver - his abilities, his habits, his expectations and natural and learned reaction in different driving situations." (Thillainayagam, 1972, p. 83).

Rothengatter (1987) argues convincingly that many accidents which superficially appear to have no human error content can actually be traced back to human error at some stage. One of the examples given is that involving a trailer becoming detached from the truck that was transporting it. Although the immediate reaction may be to classify this type of accident as being due to mechanical failure, it may have been due at least partly to the driver failing to check the connection before leaving or to a fault in the assembly process of a component. As Rothengatter goes on to suggest, this is a considerable problem as human beings are notoriously difficult to subject to controlled experimentation and can be somewhat adverse to major changes of behaviour.

The next section discusses the methods in which researchers have studied problems in driver behaviour and is followed by a section discussing how behavioural change might be brought about.

1.2: APPROACHES TO THE STUDY OF ROAD SAFETY AND DRIVER BEHAVIOUR

1.2.1 Accident Investigation

1.2.1.1 Use of Accident Data

In order to bring about a reduction in the number of road accidents it is clear that the accidents and their underlying causes should be subjected to investigation. One of the main areas of study in previous years has been the accidents statistics themselves, often as a background to further investigative techniques, but also as a sole source of information. Police accident records are generally the main source of accident data in most countries, although the type and level of information collected by the various police forces may differ considerably. For example, a survey on a number of European countries by Ercoli and Negri (1985, cited by Grayson and Hakkert, 1987) found that hour and date of the accidents were the only variables recorded by all police forces. In fact, as little as 7% of all variables were recorded in three countries and only the police records of one country was able to claim up to 70% of all items recorded. The main problem with this type of information when it comes to behavioural research is that information concerning the drivers themselves tends to be very sketchy, often being restricted to age, sex and severity of injuries sustained (Grayson and Hakkert, 1987).

However, the potential value of accident data to researchers is only too clear. For example, a reliable accident database would enable vulnerable groups within the population to be detected and therefore provide a target group for training programmes or publicity. An additional function is the assessment of remedial measures, in which the effects of those measures can be evaluated by comparing accidents in 'before and after' studies.

1.2.1.2 Inadequacies of Accident Data

Although attempts have been made to standardise the format of the data collected, particularly in the United States and Canada, they have not been very successful. However, it is not merely the lack of a universally-applicable database that has implications for the researcher wishing to utilise accident information. If accident records are used as a basis for the adoption of certain types of accident reduction schemes, it is essential for that data to create an accurate picture of the accidents it represents.

According to Hakkert and Hauer (1988), one of the main problems with using accident data is that under-reporting of accidents can distort the true extent of the problem. Comparing police records with a wide variety of alternative sources such as hospital admissions, insurance companies, employers' records and self-reports, they concluded that the police fail to receive notification of 20% of accidents producing injuries that required hospitalization and possibly up to 50% of those not requiring hospitalization. A more recent study by Stutts, Williamson, Whitley and Sheldon (1990) compared the figures for cyclists admitted to a hospital emergency room with those from the North Carolina state accident files. The researchers found that only 10% of the emergency room cases were found in the state files.

Other authors have noted that several factors appear to be implicated in the probability of an accident being reported. Hautzinger et al. (1985, cited by Hakkert and Hauer, 1987) found that the chance of an injury received in a road accident being reported increases with age, ranging from 20-30% for young children to 70% for people over 60. Similarly, Smith (1966, cited by Hakkert and Hauer, 1987) discovered that multi-vehicle accidents have a considerably greater chance of being reported than single vehicle accidents (96% and 57% respectively for injury accidents).

An additional problem concerns the accuracy of the information recorded about the accidents that are reported. A study by Shinar, Treat and McDonald (1983) compared the accident information contained in police files with that collected by multidisciplinary accident investigation (MDAI) teams (see Section 1.2.2). Along with the discovery of quite large discrepancies in identification of accident causation factors, they found that the recording of basic demographic information was often inaccurate. For example, 11.6% of drivers' ages and 5.3% of vehicles' ages were misclassified, with a further 9.7% of vehicles' years of registration not recorded.

With these considerable inadequacies in the accident records it is clear that alternative sources of information upon which to base corrective programmes are needed. Before continuing with a discussion of the various methods used by researchers to investigate driver behaviour, the next section will briefly outline the role of multidisciplinary teams in accident investigation.

1.2.2 Multidisciplinary Approaches to Accident Investigation

The use of multidisciplinary teams in accident investigation began in the late 1960's in an attempt to overcome some of the inadequacies outlined in the previous section. By definition, the teams are made up of specialists from a variety of backgrounds. Using the entire range of specialist knowledge drawn from the members of the team, the aim is to arrive at a consensus concerning the causal factors of accidents, and to suggest appropriate countermeasures.

According to Baird and Flamboe (1975, cited by Grayson and Hakkert, 1987), perhaps the most sophisticated use of multidisciplinary teams is in the study of accidents using the 'tri-level' concept. The data produced by this approach tends to be both qualitative and quantitative, and consists of the following levels:

Level 1: Basic reporting of accident data by the police;

Level 2: Trained technicians investigate a small sample of accidents of certain types according to pre-selected research topics;

Level 3: Use of multidisciplinary teams to investigate a limited number of accidents.

Treat (1980) reports on a tri-level study carried out at the Indiana University Institute for Research in Public Safety during the early to mid-seventies. Of over 13,000 police-reported accidents, some 2,258 were subjected to investigation by technicians on the scene, whilst 420 were investigated by multidisciplinary teams. This final level of analysis revealed that human factors were clear causal factors in 70%, vehicle factors in 40%, and environmental factors in just 12% of the accidents. The multidisciplinary teams highlighted improper lookout, excessive speed, inattention, improper evasive action and internal distraction as the most common human factors implicated in the accidents.

The Transport and Road Research Laboratory (TRRL) used multidisciplinary teams in a series of on-the-spot accident investigations in the late sixties in Southern England (Kemp, Neilson, Staughton and Wilkins, 1972). The main advantage of this study was that, due to arrangements that had been made with the police, the team received a telephone call the moment the accident was reported to the police and hence could send representatives to investigate an accident almost as soon as it occurred. A total of 247 accidents were subjected to this kind of investigation and the team concluded that both road and vehicle factors were implicated in around 25% of accidents, whilst human factors were found to be involved in almost 75% of the accidents studied. In addition, they were able to suggest several remedial measures to reduce the accident rates at some of the locations.

The use of multidisciplinary teams clearly has some considerable advantages, such as the ability to collect details on the "finer points of accident causation" which may otherwise remain concealed if the accident had been investigated by teams with a limited range of specialisation (Grayson and Hakkert, op.cit.). However, there are also several disadvantages with this system which restrict the frequency of its' adoption. The operational costs of these teams are necessarily high, and employing more specialists to obtain a more accurate accident assessment clearly increases these operational costs. Personnel and financial limitations also ensure that the range of accidents investigated, both geographically and typologically, is also limited, and consequently there tends to be a bias towards injury accidents within a small radius of the team's centre.

Many of the studies quoted by Grayson and Hakkert have produced relatively little useful information considering the costs of the investigation techniques employed and they suggest that multidisciplinary teams may only be a useful alternative for some specific areas of study. These might include emergency treatment of road accident casualties or the influence of roadside obstacles and road design, and it is suggested that other techniques must be used to increase understanding of the underlying causes of road accidents. The following section will discuss some of the approaches adopted by behavioural scientists in this attempt to investigate the root causes of accidents.

1.2.3 Behavioural Approaches

1.2.3.1 A Brief History of Behavioural Road Safety Research

Road safety research in the early to mid 1960's still placed the emphasis upon answering safety issues by making changes to the vehicle and road environment. Consequently, many of the studies conducted during this period were predominantly technology-based. However, this phase was accompanied by an upsurge in the study of human information processing which, as Michon, puts it could be applied to:

"...the idea that the road user can best be considered as a control element in a a complex system that also includes the road, the vehicle, the natural environment, and the traffic code." (Michon, 1988a, p. 28).

The following period saw an increase in the use of instrumented vehicle and test-track studies in an attempt to isolate factors contributing to certain driving skills in a controlled environment. The shortcomings of such approaches will be discussed in Chapter 3, but it is sufficient to point out that the majority of test-track studies were inadequate in that they failed to simulate the full complexity of the driving situation.

The early to mid-seventies were notable for the contribution of more theories based upon cognitive principles and the change of emphasis from the driver's task performance to the way in which drivers represent the information that forms the basis of these task performances. The driver as problem solver has offered many useful pointers for the future direction of road safety research and the contributions of decision theory and problem solving approaches will be discussed briefly in Section 1.6.

This emphasis on cognitively-based theories has continued throughout the Seventies and Eighties and many researchers (such as Michon, op.cit.) feel that higher-level cognitive processes and motivational factors should receive considerably more attention in the study of road user behaviour. As previously noted, these issues will be dealt with in greater detail in a subsequent section, however the next section will briefly discuss some of the groups of road users that have received special attention in recent years.

1.2.3.2 Target Groups for Behavioural Studies

The group of road users that tend to be more implicated in accidents than any other group are young, or novice, drivers (see Section 1.4.2). These are generally classed as being between 18 and 24 years of age and are an obvious target for the road safety researcher. However, it is important to draw the distinction between age and experience as explanatory factors for accidents. For example, a study of young cyclists by Vilardo and Andersen (1969, cited by Rothengatter, 1987) found that the peak accident-involvement period occurred after 2 to 3 years of cycling experience.

Another target group for investigation are elderly drivers for whom accident-involvement rates increase when exposure factors are considered (Rothengatter, 1987). The ageing process involves a certain amount of deterioration in perceptual-motor functions, decision-making skills, attention and memory and, as these skills are all involved in driving, the older driver becomes increasingly vulnerable. However, this deterioration of function is not always supported by research. For example, Van Wolffelaar, Rothengatter and Brouwer (1987) found that, whilst more elderly subjects performed less ably on both a lane tracking task (a low-level control task) and a gap acceptance task (a high-level control task), they compensated for this by selecting extreme lane positions and more conservative decision criteria. In other words, it appears that these drivers were fully aware of their impaired abilities on these tasks and were able to compensate accordingly.

The study of individual differences is an approach that has been employed to detect particularly liable road users, an issue that will be dealt with in greater detail in Chapter 6 (Section 6.4). The majority of these studies attempted to identify personality traits that could be linked to high (or low) accident involvement, although no significant trends were revealed (Rothengatter, 1987).

The direction of individual difference research is now more in line with much of the other work in driver behaviour research in that the focus is now very much upon differences in cognitive processes.

Once again, the study of such differences will be discussed in greater detail in a subsequent section. However, it is argued that the methods by which behavioural change in drivers may realistically be brought about must be discussed, as these will undoubtedly affect the direction and emphasis of the research.

1.3: INFLUENCING ROAD USER BEHAVIOUR

1.3.1 Background

The previous section outlined some of the techniques that have been used by researchers in order to investigate road safety issues. However, before deciding upon the most appropriate way of approaching a particular area of study, it is argued that consideration must be given to the intended aims and objectives of the investigation as these should have a significant contribution to make to the direction taken by the research.

One of the most important such considerations is the form preventative or remedial measures should take. Having highlighted a particular problem area or vulnerable group of road users, the researcher is generally interested in attempting to alleviate the problem by finding ways in which the behaviour of the road users in question may be altered. Traditionally, there are three main approaches: enforcement; engineering; and education, and the following sections will deal with each issue in turn.

1.3.2 Enforcement

There are two basic forms of enforcement strategy available: deterrence (which can be either general or specific) and detection. General deterrence relies on drivers responding to high profile surveillance activities (such as police car presence) or legislation by engaging in more compliant behaviours. In fact, the evidence suggests that the introduction of legislation to outlaw some forms of road user behaviour can be highly effective. For example, Dean (1981) reports that, following the introduction of a law in 1972 prohibiting 16-year-olds from riding motorcycles with engine capacities over 50cc, the annual figures for fatal and serious injury accidents involving these road users was reduced by 1200. Specific deterrence is concerned with the effect of punishment on individuals convicted of driving offences, this punishment theoretically increasing their sensitivity to the behaviour for which they were convicted, and thereby reducing the likelihood of recidivism.

The detection strategy simply aims to increase the probability of non-compliant drivers being detected whilst engaging in the illegal driving practice. The practical problems of this latter approach should be apparent given the large numbers of drivers currently using the roads, and it would be unrealistic to expect the police to provide the extra resources that would be necessary to make a significant impact upon the detection rate. The alternative is clearly to alter drivers' *perceived* level of detection to such an extent that drivers are more highly motivated to comply with the traffic laws than not to comply. In fact, a study by Riedel, Rothengatter and de Bruin (1986, cited by Rothengatter, 1987) found that an increase in the perceived intensity of surveillance activity significantly increased the effectiveness of the actual police surveillance, the level of which remained constant throughout.

Although it is clear that, in some cases, the use of enforcement measures may provide an effective method of reducing accident rates or dangerous driving practices, the practical implications of such techniques can be somewhat prohibitive. For example, it would be impossible for the police to detect every dangerous driving manoeuvre by maintaining a constant presence at every location where drivers indulge in such practices. In addition, it is only possible to achieve the desired increase in the perceived level of detection by extensive use of the media channels. This is more of an education issue (although it should be apparent that the education, enforcement and engineering approaches can be highly interdependent) and will therefore be discussed in Section 1.3.4.

1.3.3 Engineering

The theory behind the reduction of accident rates by making changes to the road environment states that the alterations provide the driver with fewer opportunities to make errors. Mahalel and Szternfeld (1986) suggest that many accidents occur when the performance level of the driver is unable to match the demands of the environment, and so changes made to the environment will help to prevent errors. By studying the nature of these errors, traffic engineers aim to introduce one or more of a variety of available options appropriate to a specific site. These can take the form of large-scale operations, such as changing a junction from a crossroads to a roundabout, or smaller, low-cost remedial measures such as alterations to road markings or the introduction of road signs. However, there may be side effects from this type of remedial measure and Huddart and Dean (1981) suggest that such remedial measures should only be undertaken at a particular location when an extremely well-defined pattern of accidents is found to occur and therefore appropriate corrective measures can be readily identified and implemented.

One such side effect that has received much attention in the literature during the last few years is known as 'Accident Migration', reported by Wright (1981) and having some similarities with 'Risk Homeostasis Theory' (dealt with in Section 1.6.2.4). The anecdotal evidence from traffic engineers pointed to a tendency for accidents to 'migrate' from a site that has received remedial measures to another nearby site. In an attempt to provide some empirical evidence to support these claims, Boyle and Wright (1984) looked at accidents at a number of sites in the London area that had received modifications over a four-year period between 1975 and 1978 (inclusive). The data revealed a 22.3% decrease in the number of accidents at these sites accompanied by a significant 10% increase in the number of accidents occurring at other sites in the immediate vicinity of the modified sites.

However, the findings of this study must be queried and the statistical techniques employed have been the subject of extensive criticism, particularly by Stein (1984). The main problem lies with the regression-to-the-mean effect. The sites were selected on the basis of their high accident rates and, as accidents rates show a great deal of annual variation, it is not surprising that fewer accidents were recorded in the period following a year with a particularly high accident rate. In these circumstances, it is not possible to determine the effectiveness of the countermeasures in reducing accident rates as this reduction may simply be a 'statistical' phenomenon. The shortcomings of the study mean that the existence of an accident migration effect cannot be neither verified nor denied. If the effect does exist, its' underlying causes remain unclear. Boyle and Wright (op. cit.) suggest that drivers compensate for the safety improvements by engaging in increasingly casual and even risky behaviours. However, no direct evidence is presented to substantiate this claim.

These reservations aside, it is clear that engineering schemes, especially small-scale projects, can be employed to great effect in some cases. An example of this type of scheme is that designed by Shinar, Rockwell and Malecki (1975) in an attempt to reduce drivers' approach speeds at a junction. The entrance road to the intersection was altered by painting stripes on a curve, making the approach more difficult for drivers to negotiate. The results showed that the drivers' average approach speed was reduced, as was the number of speeding incidents. Despite the obvious short-term success of this type of study, it should be pointed out that drivers' behaviours in the long-term must be assessed before any such scheme can be considered a success. It is suggested that the effects produced in studies such as this may simply be a product of exposure to a novel environment, and drivers may resort to their 'old ways' having acclimatised to the new junction style.

In context, the use of engineering schemes may be able to bring about a reduction in the number of certain types of accidents at certain types of locations. However, it may be remembered from Section 1.1.5 that the vast majority of accidents are due, at least partly, to human error and therefore it is argued that the ultimate responsibility for those accidents must rest with the driver. The implication of engineering factors, along with other factors such as adverse weather conditions, can often be used to obscure the fact that an accident was due to the driver behaving in a manner unsuitable to the prevailing conditions. Indeed, engineering schemes can only succeed when they bring about a reduction in the prevalence of the targeted undesirable driving practice. Therefore, it seems logical that the most effective method of dealing with road safety issues is to attempt to remove the inappropriate behaviours from a driver's repertoire altogether, or to ensure that these behaviours are not adopted in the first place. Because of this, some researchers feel that the most effective method of achieving behavioural change is via the educational approach.

1.3.4 Education

The field of road user education can be subdivided into two separate categories: education of children and education of adults through mass media campaigns. Although children may be limited to participating in the road system as either pedestrians or passengers, they are forming their attitudes at these early stages and this means that the attitudes and behaviours adopted as a child may have a significant effect on a person's approach to driving later in life. It should be clear, therefore, that good pre-school education programmes may play a vital role in ensuring that the 'correct' attitudes towards road user participation are developed. Dean (1981) suggests that, primarily, road safety education should be the responsibility of parents, not only by explaining the correct way to behave as a road user, but also, perhaps more importantly, from teaching by example.

Publicity campaigns have often been used to aid parents with their children's road safety education. For example, the Royal Society for the Prevention of Accidents (RoSPA) introduced the 'Tufty Club' in 1961 which provided materials based on animal characters to help get the messages across. Another such aid to children's education was the introduction of the 'Green Cross Code' in 1971 which reduced the essential information required to ensure safe road crossing to a few easily memorable rules. Dean (op. cit.) reports that the three month period following the introduction of the 'Green Cross Code' showed the number of child pedestrian casualties to be 11% below expectation. Although such a reduction in accidents can never be directly attributable to the effectiveness of the code, the evidence was encouraging.

Education programmes have also been developed for the most active participatory group of young road users - cyclists. RoSPA introduced the National Cycling Proficiency Scheme in 1947 as a purely skill-development training programme. In more recent years, however, the emphasis of the scheme has been broadened to include material aimed at attitude development. Although the scheme has the considerable advantage of allowing children to become responsible road users at an early age, it seems likely that the vast majority of young cyclists on the roads today have not been involved in the scheme.

Road safety education for adults generally takes the form of mass media publicity campaigns aimed at correcting undesirable behaviours. One such example in Britain is the increased exposure given to drink-driving material during December that is aimed at reducing the number of alcohol-related incidents that tend to be most prevalent during the Christmas and New Year periods. However, many researchers tend to be quite cynical about the effectiveness of publicity campaigns. For example, Huddart and Dean claim campaigns have limited use because they are:

"...by their nature relatively expensive and have to fight the entrenched driver attitude that 'it won't happen to me'." (Huddart and Dean, 1981, p. 51).

However, it is argued that, in some circumstances, publicity campaigns can be used to good effect. Rooijers (1986, cited by Rooijers, 1988) reviewed a number of evaluation studies of mass media campaigns and found that the most effective campaigns were those performed in conjunction with either an increase in the amount of law enforcement or an incentive system. The problems with the latter approach are all too evident: removal of the incentive tends to be accompanied by a return to the behavioural patterns the programme was designed to overcome.

Combinations of publicity campaigns and increased law enforcement can be a more effective method of changing the behaviour of drivers. A study by Gundy (1988) looked at the incidence of seat-belt usage before and after an extensive local media campaign demonstrating the advantages of wearing seat-belts, during which the level of police surveillance was dramatically increased. Over 28,000 drivers were observed during the course of the study and the results showed an increase in the amount of seat-belt usage, ranging from 15% to 25%, when the 'before' and 'after' figures were compared. Assessments of the incidence of seat-belt usage were also made two years after the end of the original campaign revealed the same level of usage that was observed eighteen months previously, suggesting that the positive effects of the combined campaign were not restricted to the short term.

More recently, researchers are beginning to concentrate on changing drivers' attitudes, rather than their behaviours, and these issues will be dealt with in greater detail in a subsequent chapter (6). This section has concentrated on remedial programmes for re-educating drivers, but an alternative (or additional) approach is to alter the way in which drivers are trained from the start. This topic forms the majority of the next section.

1.4: DRIVER TRAINING

1.4.1 Driving Skills

For drivers to be able to participate in the road system with a maximum level of safety, they must have acquired certain social and technical skills to call upon when responding to situations encountered in that road system. A driver who is lacking in any of these areas can be said to have an increased probability of being involved in an accident. These skills can be divided into three main categories: perceptual-motor skills; rules-based skills; and knowledge-based skills (Brown, Groeger and Biehl, 1987, based on work by Rasmussen, 1983).

The first category ensure that the driver has full control of the vehicle and has a working understanding of its' handling characteristics. Also essential to being a successful traffic participant is a thorough understanding of the traffic laws governing road users' behaviours. The final category concerns the more judgemental, decision-making skills and knowledge about the characteristics of the traffic system components that are essential for successful interaction with other road users. It can be argued, therefore, that a thorough training programme should concentrate on development of all three skill categories to ensure that newcomers to the traffic system have a wide-ranging and well-balanced set of skills on which to build as more experienced is acquired.

1.4.2 Effectiveness of Current Methods of Driver Training

It has already been noted that the vast majority of road accidents can be attributed, at least partly, to human error. A study of contributory factors to road accidents in Great Britain conducted by Sabey and Taylor (1980) revealed that the human factors which accounted for most accidents included: lack of roadcraft; misperception of traffic hazards; driving too quickly for the prevailing conditions; failing to observe the correct give way procedure; close following; and poor overtaking manoeuvres. To suggest that these accidents were mainly caused by drivers behaving in a reckless manner is too simplistic, and it more appropriate to think of them as being caused by drivers failing to appreciate certain hazardous situations or responding to these hazardous situations in an inappropriate manner. A truly effective training programme would ensure that drivers were equipped with a knowledge of a wide range of such hazardous behaviours and situations and how they can be best dealt with or avoided altogether.

Driver training, particularly in this country, generally consists of a course of lessons with a registered driving school, often with the addition of private tuition from a friend or relative, followed by a driving test. Unlike some countries (eg. Germany), additional professional training courses are not compulsory in Great Britain, and the number of drivers volunteering for such courses is very low. The driving test, therefore, remains the sole method by which a driver's ability to meet the demands of unsupervised driving on the road is assessed.

However, driving tests are generally geared towards the handling skills and rule-based components and provide little or no opportunity for drivers to learn about the knowledge-based aspects of driving. In addition, the mistakes made by drivers during their tests may not be indicative of the types of errors made after qualification. For instance, Sheppard, Henry and Mackie (1973, cited by Brown et al., 1987) found that the types of faults made during the British driving test did not correspond with those contributing to these drivers' subsequent accidents.

In order to assess the current method of driver training in this country in terms of its' ability to equip drivers with the aforementioned skills, it is necessary to study the accident-involvement statistics of newly-qualified drivers. Pelz and Schuman (1971) studied accident-involvement in relation to the time-lapse since qualification. They found that, when age, experience and exposure factors were taken into account, the peak accident-involvement period occurred around two to three years after qualification, gradually declining from that point onwards.

Alternatively, a study conducted by Williams (1985) demonstrated that, when mileage was accounted for, an approximately linear inverse relationship exists between age and involvement in fatal road accidents. This relationship, contradicting Pelz and Schuman's (op. cit.) finding, was found to remain true up to the age of 50, beyond which an increase in the 'fatal accidents-per-miles driven' ratios was noted. However, it is plausible that the discrepancy between the studies lies in the fact that the Williams study focused upon fatal accidents, whereas Pelz and Schuman were concerned with all accidents. Whatever the 'peak' age for accident-involvement, it is clear that the current methods of driver training may leave young and newly-qualified drivers with poorly-developed abilities to deal with the demands of the traffic system. As Brown, Groeger and Biehl (1987) state:

"...the skills acquired by drivers during training leaves them ill-equipped to deal with the increasing demands they make upon themselves in traffic as their driving experience and use of their vehicles increase." (Brown, Groeger and Biehl, 1987, p. 138).

The effectiveness of professional driving schools in comparison to other forms of pre-test tuition has also been called into question by some researchers. For example, Skelly (1968, cited by Brown et al., 1987) compared the accident rates of drivers who had received tuition from one of three alternative sources: a driving school; a friend or relative; or a combination of the two sources. When mileage exposure was controlled for, Skelly found that the drivers who had been taught by a friend or relative only had a higher mileage to accident ratio (ie. drove more miles per accident) than drivers who had received tuition from a driving school. The third group of drivers, those who received a mixture of the two methods of training, had the worst accident record of all.

The evidence suggests that there may be some inadequacies in the current methods of driver training available, and it is felt that alternative or additional sources of training should be explored.

1.4.3 Additional Professional Training Courses

One of the ways in which general driver training may be improved is through adoption of additional training methods. A study by Lund, Williams and Zador (1986) looked at the effectiveness of an enhanced driver education programme for high-school students. Although the students who completed the course were more likely to pass the driving test than a control group, they were also found to be more likely to be involved in accidents. A similar study conducted on young French drivers by Simonnet, Delaunay and Forestier (1982) investigated the advantages of accelerated courses of intensive instruction in addition to the standard method of instruction. The results showed that drivers who had received the additional training showed no major changes in their attitudes and behaviours.

The British Institute of Advanced Motorists runs a course aimed at training drivers to a higher level than that provided by the standard driving test. The police also run a similar training programme, known as the 'Better Driving' course, aimed at improving perceptual and decision-making skills. Evaluative studies of the effectiveness of such courses in this country are somewhat thin on the ground, but one study by Fazakerley, Davies, Henderson and Sheppard (1980) found that the 'Better Driving' course did tend to produce a considerable improvement in drivers' knowledge and performance. Unfortunately, no investigation of the course's effect upon subsequent accident rates was carried out.

As already noted, additional training courses are now compulsory in Germany and extra instruction in topics such as motorway and night driving are also required by law. In theory, the accident rates of German drivers should be favourable when compared to a similar group of drivers from a country without compulsory additional training. Tight, Hakkert and Allsop (1986, cited by Brown et al., 1987) compared young drivers in Germany (then West Germany) with a similar group of British drivers and found that the German drivers had a casualty rate that was more than twice that of their British counterparts. This rather surprising finding, in conjunction with the conclusions of the other studies cited, suggests that the type of additional training methods outlined here do not have a beneficial effect on the way in which young drivers conduct themselves on the road, and may even appear to have a detrimental effect in some cases.

However, before conclusions can be drawn about this issue, it is worth noting that many of these studies have certain methodological shortcomings which may detract from the more immediately obvious conclusions. For example, as Brown, Groeger and Biehl (op. cit.) point out, the differences in casualty rates noted in Tight, Hakkert and Allsop's comparative study on German and British drivers may be due to cross-cultural factors, such as the absence of a nationwide speed limit in Germany, that could not be controlled for.

1.4.4 Re-Testing of Offenders

Although the evidence suggests that additional professional training courses such as those outlined in the previous section do not have a positive effect on accident rates, it may be possible that such training courses could be used to greater effect if they are used to enhance skills that are known to be deficient in certain drivers. Defensive driving courses have been developed to teach drivers how to avoid the types of errors they are known to have made from the evidence of their driving convictions. However, if it is assumed that the ultimate goal of such courses is to reduce the number of accidents, serious problems are evident in this logic. One of the major problems with this approach is that the relationship between involvement in traffic offences and accidents is unclear. For example, Miller and Schuster (1983) found that the former was a poor predictor of the latter. Alternatively, Harano, Peck and McBride (1975) investigated a number of demographic details and performance scores on a variety of psychometric tests in terms of their ability to predict accident-involvement. In the initial multiple regression analysis, the number of traffic convictions held was the second most effective predictor (behind a socioeconomic scale) of accident-involvement. It should be noted that the discrepancy between these two studies may be a result of the fact that the Miller and Schuster study investigated the predictive ability of traffic offences that were typologically related to the accidents correlated with. However, the Harano et al study did not distinguish between offence or accident types.

As a result of this confusion, it is perhaps not surprising that, of the methodologically-sound defensive driving evaluation studies reviewed by Lund and Williams (1985), none were found to demonstrate a reduction in the subsequent accident rates of participating drivers. Significantly, however, the number of traffic offences committed by these drivers after the course was reduced by around 10%. Although reducing the number of traffic offences has to be a consideration for road safety researchers, it is argued that the primary objective must be to focus upon accident-reduction, and that this should also be the main concern of training programmes.

1.4.5 Improving Driver Training

Whilst the evidence presented here suggests that the results of current approaches to driver training fall somewhat short of expectation and that there is considerable scope for improvement and enhancement, many researchers are optimistic about the possibilities. In the words of Michon:

"...it is generally believed...that a more sophisticated approach to instruction will eventually allow us to capture the essence of what constitutes good driving, and to transfer this to the learning driver." (Michon, 1988b, p. 508).

However, it has been suggested (Brown, Groeger and Biehl, 1987) that a more detailed understanding of the driver's task has to be gained before appropriate suggestions for future training programmes can be made. This would not only include information concerning the demands imposed on the driver by the task, but must also take into account the range of skills with which the driver is equipped to meet these demands and how these change with increased experience. Equally important to the understanding of the factors leading to accident-involvement is an understanding of the way in which drivers acquire the necessary skills to become a successful (ie. safe) traffic participant.

Quite clearly, one of the first stages required by an investigation of these issues would be a study of the nature of the errors being made by drivers. The next section will deal with recent approaches to the study of errors, initially concentrating on general approaches, followed by those specifically relevant to driving.

1.5: DRIVER ERROR AND ERROR MODELS

1.5.1 Classifying Driver Errors

The previous section discussed the inadequacies of the current methods of driver training, and it was argued that a more thorough understanding of the errors made by drivers was required before appropriate alterations to training programmes can be suggested. One of the most comprehensive studies of driver error was conducted by Harvey, Jenkins and Sumner (1975), who applied three methods of studying driver behaviour to the classification of errors: in-car observation of errors made by drivers on a specified route; external video recordings of vehicles using the same route; and finally time-lapse photography of a larger sample of vehicles at selected sites from the route used for the previous two studies.

Each of the resulting 80 observed error types was allocated a severity rating by the researchers and positive correlations were found between the number of errors made, their level of severity and the accident incidence at each location. The most frequently observed error was following too closely behind the vehicle in front, whilst many of the more common errors involved poor overtaking manoeuvres. The study had the distinct advantage of using a number of alternative techniques to obtain a comprehensive list of errors. However, it would have been more advantageous to have used all three techniques simultaneously on the same sample of drivers so that the behaviours of drivers observed during the in-car study could be directly linked to the external consequences of these behaviours in relation to other road users.

Although the Harvey, Jenkins and Sumner study provided an extremely useful basis for the classification of driver errors, it was a purely behavioural study and could add little to a deeper understanding of the cognitive and motivational processes behind the observed errors. In addition, the researchers limited themselves to recording inappropriate behaviours, and it is suggested that, before a complete understanding of errors can be achieved, the relationship between driving errors and behaviours producing no errors must be investigated.

There has been considerable attention focused upon the study of human error within the last few years and it is felt that investigation of some of these human error models, particularly those specific to driving, may be able to provide valuable information for the current study. Therefore, the following sections outline some of the more relevant approaches.

1.5.2 Human Error Theories

According to Reason (1979), it is the failure of 'planned actions' to achieve a desired outcome that is central to the concept of error. If an accident results from an intervention by a chance factor, the term 'error' cannot be used to refer to the cause of that accident and Reason argues that all actions are governed by plans. A plan was defined as a:

"...mental representation of both a goal (together with its intermediate sub-goals) and the possible actions required to achieve it." (Reason, 1979, p. 69).

Plans which have similar components share a certain amount of 'space' in the representation, but branch away from each other when the demands of these actions begin to differ. The plans and branches have associated 'strengths' depending on how successfully and recently each plan has been used.

The whole network of plans is controlled by 'open-loop' and 'closed-loop' systems. The former category is more automated and therefore requires no feedback for successful operation, but a plan controlled by an open-loop system may need much practice and will tend to be resistant to adaptation to novel situations. The closed-loop system is dependent on feedback and progress onto each stage of the plan must be preceded by positive feedback. Although this system allows for more careful monitoring of the task, the amount of resources allocated to the processing of this information must necessitate allocation of fewer resources to other operations and the delay caused by this monitoring of feedback will not be ideally suited to situations requiring an immediate response. Reason suggests that the ideal way of operating is to use both open and closed-loop control modes interchangeably, and therefore the skill lies in being able to switch between the two modes effectively.

This theory states that errors will occur when the plan selected is unable to meet the demands of the task. Reason (1984) distinguishes between four main classes of error: slips; lapses; mistakes and violations. The latter category has two sub-categories, depending whether the violation in question was intended or not. Slips occur when a strong habitual sequence of events is disrupted in some way, either by intrusion of new elements or when the sequence is aborted prior to completion. Lapses, which may be thought of as being a sub-category of slips, also result from omissions from a recognised sequence of events but may distinguished from slips in that the omitted element is not replaced. Both slips and lapses are examples of unintended actions, where an error is only noticed after the action has been performed and therefore does not allow for corrective procedures to be made. Reason (op. cit.) argues that the types of errors leading to small, everyday slips may be fundamentally similar to those leading to major disasters, and it is only the particular circumstances that distinguish between the two.

In contrast, for both mistakes and violations, failure results from inappropriate construction of intentions. Mistakes can be differentiated from violations in that the former imply a failure to perceive a situation in an appropriate manner, whilst the latter imply that the perpetrator has a clear idea that an unsafe act is being performed, but simply does not realise the hazardous potential of the circumstances. Mistakes may be further sub-divided into rule-based mistakes and knowledge-based mistakes as suggested by the 'skills-rules-knowledge' framework outlined by Rasmussen (1983).

Whilst Reason's approach offers a useful means by which different error types can be classified, it has been argued by Groeger and Brown (unpublished) that it does little to specify the mechanics of its' operation, and it is therefore unlikely that it could be applied to the field of error prediction. In addition, the ways in which the 'plans' are structured and represented are not specified. However, recent research by Reason, Manstead, Stradling, Baxter and Campbell (1990) has demonstrated that these distinctions *can* produce useful clues concerning the underlying processes implicated in driver error. In this survey, over five hundred drivers were asked to rate the frequency with which they committed a number of errors (ie. slips, lapses and mistakes) and violations when driving. The resultant principal components analysis revealed a clear distinction between errors and violations, producing three factors relating to violations, dangerous errors and harmless lapses. The researchers concluded that whilst these findings did not constitute evidence of a solid distinction between their underlying psychological processes, they were consistent with this possibility. However, this approach still does not reveal the nature of these underlying psychological processes, and it is argued that, for the purposes of accident prevention, it is more important to understand *why* errors occur, rather than that they can be distinguished from violations.

A more recent approach for identifying errors offered by Reason is the Generic Error-Modelling System (GEMS) (Reason, 1987), which uses Rasmussen's (op cit.) 'skills-rules-knowledge' classification of mistakes as a basis for locating a system's areas of limitation and sources of bias that lead to more common forms of error. GEMS (see Figure 1.1, over) deals with two basic areas: operations which precede detection of a problem in the system; and operations which follow this detection. The former are classed as monitoring failures, whilst the latter are seen as more general problem-solving failures.

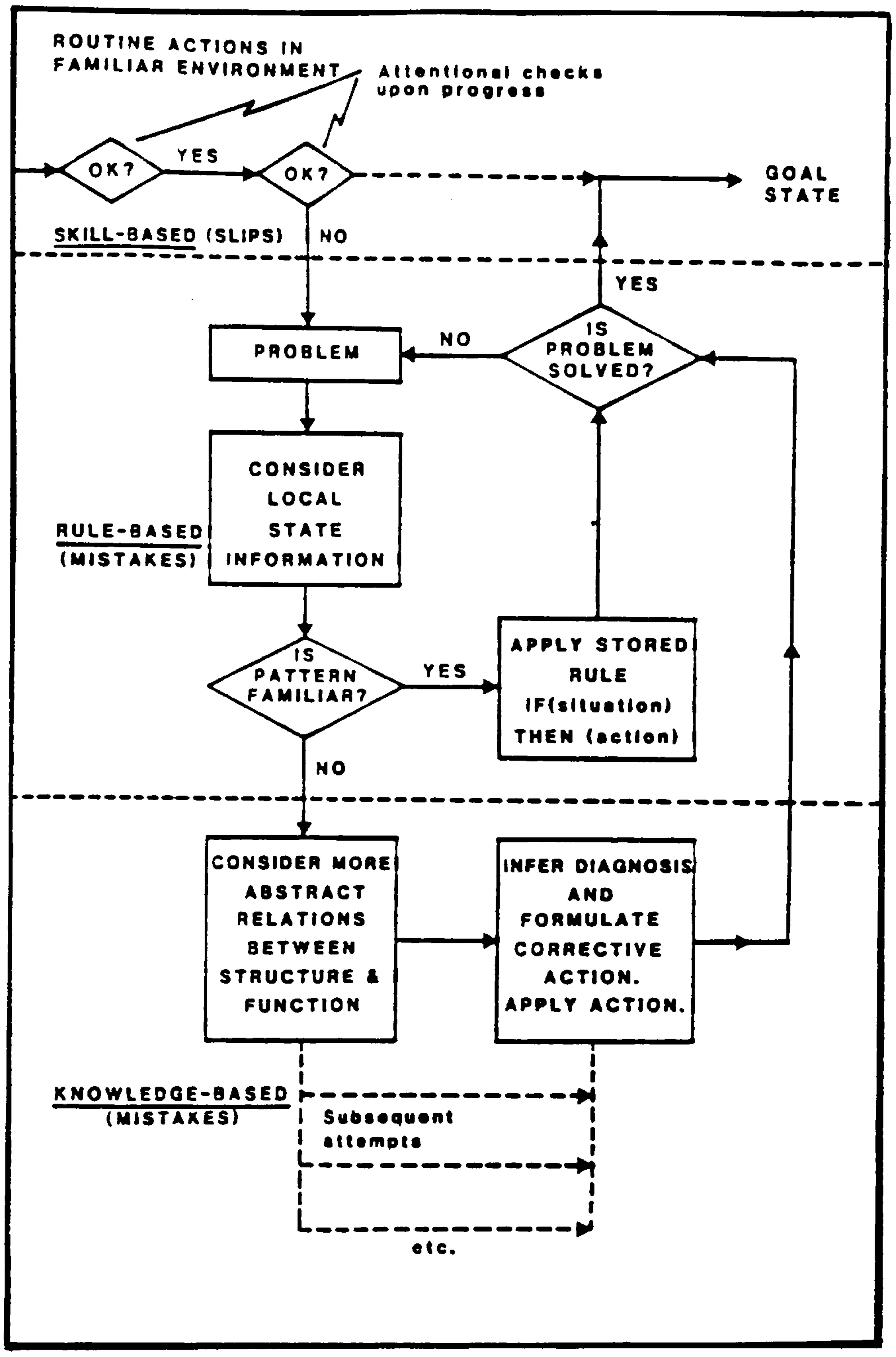

Figure 1.1: The Generic Error-Modelling System (from Reason, 1987)

An intrinsic part of the GEMS model is the way in which an operator switches between the skill-, rule- and knowledge-based modes of behaviour. At the skill-based level, activities follow highly routinised patterns in a familiar environment. The rule-based level is invoked when an attentional progress check detects an error in the system, returning to skill-based activity if a suitable corrective rule is found to deal with the situation. However, if no such rule is available, GEMS implies that the operator then seeks to derive a rule from a mental model of the entire system. If the product of this search through the mental models provides a suitable corrective procedure, the operator returns to skill-based activity. However, if the procedure is not appropriate to the circumstances, the model suggests that the operator will continue switching between modes until an appropriate solution is found or an inappropriate solution is implemented. The system allows for new information to become incorporated so that, should a 'new' rule derived from more abstract knowledge-based components be found to be a suitable way of dealing with a particular situation, it may then be 'promoted' to the rule-based level of representation.

GEMS provides a useful framework in that it is able to explain differences between experts and novices. According to the model, experts will be in possession of a larger set of rules, formulated at a more abstract level so that general principles may be applied to novel situations with greater effect. Clearly, for the purposes of subsequent research, the important feature of the GEMS model concerns the mental representations and their accuracy, generalisability and adaptability.

A related approach, also posited by Reason (1990), aims to develop a more thorough understanding of the circumstances under which errors are more likely to be made. The theory was mainly developed to study errors made in complex systems, in industrial settings for example, but has some relevance in the context of this section of the literature review. Reason distinguished between 'active failures', the performance-related failures that immediately precede an accident, and 'latent failures' which occur within 'higher-level' components of the system such as managerial or organisational sectors. These latent failures are potentially accident-causing factors that may lie dormant until a certain set of circumstances 'allow' them to emerge and increase the likelihood of an accident resulting. In a driving context, it can be argued that a particularly badly-designed section of road, an environmental factor, can be seen as such a latent factor. In this situation, an accident may not result until another factor or combination of factors, such as driving at an excessive speed along that section of road, is introduced to the system.

Primarily for use in an industrial context, Reason and his colleagues (Reason, Shotton, Wagenaar, Hudson and Groeneweg, 1988, cited by Wagenaar and Reason, 1990) have developed this notion of accident causation into a model, known as TRIPOD, incorporating Rasmussen's (op. cit.) 'skills-rules-knowledge' concept (see Section 1.4.1). In this framework, the latent failure types are known as 'General Failure Types' (GFTs). The main area of concern is to discover the relationship between these GFTs, 'unsafe acts' (ie. those which increase the likelihood of accident occurrence) and the accidents. The conventional accident analysis approaches concentrate on the link between unsafe acts and accidents, attempting to minimise the opportunities for GFTs to influence the unsafe acts. However, Reasons et al's approach attempts to uncover the links between the GFTs and accidents and hence the circumstances under which performance of an unsafe act is likely to increase the chances of accident formation. Although used somewhat out of its intended context, it is felt that the concept of the GFT may be able to contribute to the understanding of driver errors. The relevance of this and other error models to the study of driver error are outlined in the next section.

1.5.3 Applicability of Error Models to the Study of Driver Errors

According to Groeger and Brown (unpublished), perhaps the main factor behind the relative failure of many approaches to road safety is that the range of behaviours investigated at any one time has always been too small, resulting in insufficient attention being paid to the system and context in which the driver operates. Although Groeger and Brown have recognised that the relation between driver errors and error-free driver behaviour must be studied from a cognitive perspective, ie. by isolating the cognitive structures underlying both classes of behaviour, they do not feel that any of the current modelling approaches are individually sufficient to explain such behaviours. However, they do suggest that the theories reviewed in the previous section may be useful in providing a framework for future investigations.

Although the models outlined in the previous section all have their shortcomings in terms of their abilities to account for the underlying structures implicated in errors, it is suggested that they are not mutually exclusive models and, to a certain degree, it may be possible to combine the principles incorporated within them. For example, Hudson and Reason (unpublished) feel that the TRIPOD model of accident causation can be used in conjunction with the error-classification approaches devised by Reason and Rasmussen, an intrinsic part of the GEMS framework. To account for the fact that their model had little to say about the nature of errors, Hudson and Reason posited the notion of 'psychological precursors', including inattention, haste or lack of knowledge, which are a product of the General Failure Types. The type of precursor which has an effect in any particular situation is determined by the type of behaviour, as defined by Rasmussen (ie. skill, rule, or knowledge-based), in operation at that time. In the words of Hudson and Reason:

"The GFTs and psychological precursors are already present when an individual appears on the scene and it may not matter which particular person has been selected to be the victim. It is very late in the accident process that a person may make one unlucky unsafe act which, combining with the local situation, may slip past the last-ditch defences and suddenly lead to an accident." (Hudson and Reason, unpublished, p. 3).

A problem with Reason et al's approach is that it does not account for the initial appearance of a GFT or psychological precursor. In other words, it cannot explain which factors are implicated in the formation of GFTs and precursors, and which determine those factors that appear in certain circumstances. It is felt that such theories lack a vital element: the ability to account for the underlying cognitive processes in operation, and it is suggested that it is these underlying structures that should provide the focus for investigation.

Rasmussen (1987) differentiated between the causes and the reasons behind an accident. The former refer to the component of the action that actually led to the error, whilst the latter refers to the adoption of a particular course of action and the intention behind the adoption of that action. Although it may be assumed that the causes of errors committed by experienced and novice drivers will be identical, the GEMS model suggested that experienced drivers should have a more complete understanding of the task in hand, and therefore it is hypothesized that the reasons behind errors made by experienced and novice drivers will have fundamental differences. Therefore, some researchers (eg. Groeger and Brown, op cit.) feel that such studies of errors must take factors such as driving experience into account, along with standard demographic information such as age and sex. In addition, authors such as Lourens (1990) stress the role that conative components such as motivation, emotion and intention may have to play in the analysis of driver errors.

Groeger and Brown (op cit.) suggest that the most appropriate way forward for driver behaviour research is to concentrate upon studying the nature of a smaller number of errors in great detail before expanding to the study of the population of errors. This detailed study should not merely concentrate upon the actions the drivers actually carried out, but also those actions the drivers' failed to perform, the alternatives available at the time, and the drivers' intentions. However, the errors should not be studied in isolation and it is felt that the wider context in which the errors occurred must be examined.

1.5.4 Implications for Driver Training

If a serious attempt to reduce the number of errors being made by drivers is to be made, it is clear attempts should be made to note the factors that are linked to errors as early as possible and attempts made to remove them from the driver's repertoire implemented before these factors become a permanent fixture. As Brown, Groeger and Biehl (1987) have pointed out, this is highly dependent on the learner driver receiving adequate feedback and, due to their own inexperience, this feedback must come from an external source, ie. the driving instructor. As Groeger puts it:

"...feedback, or knowledge of results, ...will encourage the development of durable structures that support desirable behaviour. ...The feedback given by the instructor should be directed at producing performance sufficient to allow safe unsupervised driving which is sustainable throughout a driver's career..." (Groeger, 1988, p. 524).

The role of the instructor, therefore, should be geared more towards teaching drivers how to detect their own errors by providing continual assessment and comparing with that of a model driver. It is theorized that this form of feedback will continue to operate after qualification, constantly reinforcing the 'model' behaviours acquired during training. One of the difficulties in this approach is how to define a 'model' driver, but it is hoped that the study of errors and the differences between experienced and novice drivers should aid this definition.

Although an apparently workable framework for qualifying drivers errors has been outlined, it is felt that the literature may be able to provide further clues as to how the underlying processes discussed in this chapter may be uncovered. Therefore the next section will review the various approaches that have been adopted within the field of driver behaviour research to understand the cognitive processes at work in drivers.

1.6: COGNITIVE & DECISION-BASED APPROACHES TO THE STUDY OF DRIVER BEHAVIOUR

1.6.1 Physiological and Information Processing Approaches

In many cases, physiological measures have been used in driver behaviour research to study cognitive processes. Researchers adopting this approach suggest that the cognitive demands of a particular task will be reflected by a certain physiological measure. Among the most notable studies have been those conducted by Taylor (1964) (measuring galvanic skin response), Helander (1978) (respiration and cardiovascular output as measures of workload) and Sayers (1973) (spectral analysis of heartbeat inter-beat intervals). None of the approaches have suggested that they are able to provide a thoroughly reliable reflection of cognitive load, and the results of such studies have generally been ambiguous.

Non-physiological studies of workload have often concentrated on performance scores in dual-task experiments, in which the subject is required to perform an additional (secondary) task alongside the main task (ie. driving). The subject's ability to perform this additional task is reasoned to reflect the amount of 'spare' information processing capacity remaining after that required for performance of the primary task. For example, McDonald and Ellis (1978) displayed a series of numbers upon a screen fixed to the bonnet of a test vehicle, the subjects being asked to devote spare processing capabilities to repetition of these numbers. The study was able to demonstrate the workload demanded by a narrow range of lane tracking tasks, but it was concluded that the technique could not be adapted to a wider range of situations. A more recent study by Harms (1986), employing a similar dual-task technique, looked at attentional demands of two contrasting road environments (highway and village). The results revealed that a positive relationship existed between accident rates and cognitive load, although no effect upon driving speeds was recorded.

Other researchers have used information processing approaches to investigate other driving abilities. Quimby and Watts (1981) cite a study by Gioia and Morphew (1968) which suggested that 90% of the information acquired by drivers is supplied by the visual system. Studies which have focused upon drivers' visual perception tend to be laboratory-based simulations of the driving situation. For example, McLeod and Ross (1983) asked subjects to give time-to-collision (the amount of time taken for an observer to reach a potential point of collision with another road user) estimates in a variety of situations, presented on film, shown from the perspective of a moving car travelling towards a stationary car. McLeod and Ross hypothesized that, if it took subjects appreciable time to estimate the time-to-collision measures, the accuracy of these estimates should increase with the amount of time available in which to make the estimates. The absence of an effect due to available time led the researchers to conclude that it was information obtained from the changing optic array (ie. the optic flow method) that influenced the time estimates rather than 'lower-order', cognitive information.

Field dependence is another area of cognition that is of interest to some driver behaviour researchers. Field dependent individuals are less able to extract salient information from the overall display (background) than field independent individuals. Amongst others, the embedded figures test (EFT) devised by Witkin, Dyk, Faterson, Goodenough and Karp (1974) has been employed to assess field dependence and performance on this test has been shown to be related to accident involvement (eg. Mihal and Barrett, 1976). The implications for field dependent drivers should be apparent. A driver who is not as efficient at breaking down the components of a given road scene (ie. is 'field dependent') will be at a considerable disadvantage should one of those components constitutes a potential hazard. In addition, Brown posits the interesting possibility of the concept of field dependence being applied to the study of fatigue in drivers, as the study by Mihal and Barrett (op.cit.) suggested that such field dependent drivers may be more susceptible to driving fatigue.

1.6.2 Risk

1.6.2.1 Defining Risk

An area of research that has received a considerable amount of attention in the field of driver behaviour research in recent years, and which may in some ways be thought of as an area of cognitive psychology, is 'risk'.

The concept of risk has been responsible for a considerable amount of controversy within the field of driver behaviour research, perhaps largely due to the fact that a definition of the term cannot be agreed upon. For instance, there has been a tendency for some authors (eg. Hauer, 1982) to equate risk with the probability of accident occurrence. As Haight (1986) points out, this somewhat restrictive use of the term does not in any way account for the severity of the consequences of a particular action. For example, the outcome of a particular action may not have any adverse consequences whatsoever, yet use of the term 'risky' to describe that action does not seem appropriate, regardless of how improbable that outcome may be. The overworked illustration of this point is the comparison between playing Russian Roulette and betting on the outcome of tossing a coin. A participant in the former activity has a one-in-six chance of 'losing', far less likely than the one-in-two probability of losing in the latter activity. Therefore, if risk is to be defined purely in terms of probability, Russian Roulette can be said to be a less risky activity than betting on the toss of a coin. Not surprisingly, this is a less than satisfactory use of the term 'risk', and it is clear that some measure of the potential consequences of an action must be included in a workable definition.

Brown and Groeger (1988) propose a definition that includes a measure of the potential consequences of an action. According to them, risk is equivalent to the ratio between a measure of the adverse consequences of an event and a measure of exposure to conditions under which those consequences are likely to occur. This definition also differentiates risk from two additional terms that have sometimes been used interchangeably with it; hazard and danger. The cited definition overcomes this confusion because, as Brown and Groeger point out, these latter concepts can be thought of as characteristics of objects or events, rather than ratios between consequences and exposure estimated by the assessor. Indeed, Haight (op.cit.) feels that risk is a quantity which can only be estimated, not deduced.

As Jonah (1986) mentions, it is important to note that risk-taking behaviour does not necessarily involve volition on the part of the risk-taker, who does not necessarily need to be aware that s/he is taking a risk. This also highlights the importance of the distinction between subjective and objective risk. Objective risk is generally taken to be synonymous with 'danger', and can be thought of as a quantity that is inherent in particular events or objects, its' level being determined by experts. On the other hand, subjective risk is that estimated by the task performer and this risk level may be subject to a wide variety of influences. In the words of Brown and Groeger:

"Hazard perception...involves not only the identification of hazard, but also some quantification of the potential for danger if existing traffic manoeuvres do not proceed as expected and if the driver takes no avoiding action." (Brown and Groeger, 1988, p. 586).

1.6.2.2 Risk Assessment

One of the main considerations for risk assessment is the accuracy with which drivers are able to evaluate the riskiness of situations. There are two alternative strategies that drivers may adopt and the accuracy of risk estimation may largely depend on the strategy selected. As Haight (op.cit.) points out, the drivers may either evaluate risk on a moment-by-moment basis or on large-scale averages. Performing a particular manoeuvre (eg. driving straight through a red light) may be:

"...in general considerably riskier than not doing so, but there must be situations where the risk of injury in doing so is minimal or even zero, so that a rational being would be deterred ... by fear of arrest, social disapproval or some extraneous (to safety) consideration." (Haight, 1986, p. 362).

Studies have been carried out to assess the accuracy of drivers' risk evaluations, and the findings have been quite revealing. For instance, it has been found that, while drivers tend to have accurate perceptions of risk when considering the total driving population (Lichenstein, Slovic, Fischhoff, Layman and Combs, 1978), there appears to be a tendency for drivers to personally disassociate themselves from other drivers. Indeed, some research has shown that most drivers consider themselves to be safer and more skilful than the average driver (Svenson, 1981) as well as less likely to be involved in an accident than their fellow drivers (Svenson, Fischhoff and MacGregor, 1985). Unfortunately, as DeJoy (1989) points out, very little is known about the factors that produce this over-estimation of abilities, although his own study suggested that it may be linked to drivers' over-estimation of the amount of control they have over a particular situation. However, a more recent study by McKenna, Stanier and Lewis (1991) has suggested that the source of this bias is more likely to result from drivers' over-estimation of their own, rather than an under-estimation of others', skill.

It is suggested that, before the reasons for such inaccuracies in hazard perception can be identified, the methods used by drivers to quantify the hazard of a particular situation or object must be considered. Von Benda and Hoyos (1983) have demonstrated that this hazard perception is learned and this clearly ties in with the concept of schemata discussed in the next chapter (see also Section 1.6.4). The more experienced drivers become, the more knowledge they gain concerning the specific components of the available information which are associated with hazardous objects and events. This theory may account for the results of studies such as Mourant and Rockwell's (1972) discovery that the scanning and visual fixation patterns for novice and experienced drivers are different. In addition, Brown (1982) showed that young novice drivers were not as able to identify distant road hazards as more experienced road users, although their performances when assessing nearer hazards showed no such difference.

It appears that the internal representations of hazards, and the way that these change as more experience is gained, may enable the process of hazard perception to be more completely understood. Certainly, these internal representations must display a degree of complexity as they need to be capable of storing information about the dynamic nature of hazards (Hedge, 1987). Further clues may be provided by investigation into the ways in which risk assessment differs when comparisons between certain groups of drivers are made.

1.6.2.3 Variables Affecting Risk Assessment

The differences in hazard perception as a function of experience have already been touched upon in the previous section, and therefore this section will concentrate on other variables. Age is linked with, but not synonymous with, driving experience, and due to the over-representation of young drivers in accident records, several studies have focused upon age differences in risk assessment. For instance, Pelz and Schuman (1971) looked at age differences in accident and traffic violation incident involvement when exposure (ie. distance travelled) and years of driving experience were controlled for. They found that the younger drivers (around 18 and 19) were still involved in a higher proportion of incidents, and concluded that age itself was the most important factor in accounting for such incidents. It should be pointed out that, although this study may help to put risk assessment in perspective, it did concentrate on measures of objective risk, and it is felt that the most important measure under consideration here is subjective risk assessment.

Matthews and Moran (1986) investigated age differences in the perceptions of accident risk and driving ability given by male drivers. Younger drivers (ie. those in the 18-25 age range) rated their own driving ability and accident risk as being the same as older drivers (35-50), but thought that their peers (ie. other young drivers) were less able and more at risk than themselves. Unfortunately, age and exposure factors were not taken into account in this study. A similar study by Finn and Bragg (1986) revealed that younger driver tend to over-estimate accident risk more than older drivers, whose assessments were found to show more variability. If younger drivers believe that their chances of becoming involved in accident (ie. their subjective risk) is greater than it actually is, logic would appear to suggest that this should make them more cautious. The Pelz and Schuman study (op.cit.) clearly shows that this is not true and, as Jessor (1984, cited by Groeger and Brown, 1989) suggests, it seems that younger drivers tend to pay little heed to the objective risk of a situation. However, as Groeger and Brown (1989) point out, the undesirable behaviours in which young drivers appear to be over-represented may not be thought of as 'risky' by those drivers when asked to rate them.

A more recent study by Groeger and Brown (op.cit.) suggests that some of the studies cited may have produced rather misleading results. These authors also controlled for driving experience and found that subjects' ratings of their own driving ability did not vary with age. In addition, female and male drivers reported their own driving abilities in a similar fashion, and the small differences that were found were attributed to differences in traffic experience. However, age differences were found to influence two factors connected with the self-ability ratings: 'smoothness' and 'recklessness'. Groeger and Brown suggested that the reason why younger drivers are over-represented in accident-involvement is simply a function of their lack of experience, rather than a result of personality deficiencies or youthfulness per se. In his summary of research in this area, Jonah concludes that:

"...risk has a greater utility among youth primarily in the expression of emotions like aggression, the seeking of peer approval, the facilitation of feelings of power and control and the enhancement of self-esteem." (Jonah, 1986, p. 268).

An observation study by Ebbesen and Haney (1973) looked at variations in risk-taking behaviour at junctions due to the presence and position of other vehicles. The main factor influencing increased risk-taking behaviour was having to queue to enter the junction, whilst the presence of other vehicles behind or alongside the subject vehicle had no effect on risk-taking. These authors interpreted the findings as suggesting that social facilitation (ie. having an 'audience' whilst performing a manoeuvre) did not affect risk-taking, instead supporting a frustration hypothesis (due to being forced to wait in a queue) for increased risk-taking. However, it would appear that these conclusions are rather subjective given the nature of the study, and it is suggested that problems of this type would require a more complex investigation technique.

Cross-cultural differences in risk perception (Sivak, Soler, Tränkle and Spagnhol, 1989) and risk-taking behaviour (Sivak, Soler and Tränkle, 1989) have also received some attention recently. In a study comparing American, Spanish, West German and Brazilian drivers' risk perception abilities (from information presented on film), these researchers found that the Spanish drivers reported the highest levels of risk, with the Americans reporting the lowest. The study of risk-taking behaviour did not feature Brazilian subjects and the results showed that the West German drivers were more cautious in simulated junction crossing tasks and had a greater success rate.

While a considerable amount of research has been conducted with the field of driver risk assessment and risk-taking behaviour, none of the studies so far cited have made much of an attempt to develop the notion of risk into a general theoretical framework. However, there have been some notable efforts to do just this, and one of the major theories will be discussed in the next section.

1.6.2.4 Risk Homeostasis

Risk Homeostasis Theory (RHT) (see Wilde, 1982), states that road users have a desired level of risk, and that all driving is performed in such a way as to maintain this level, regardless of the environment in which drivers find themselves. The overall incidence of accidents is seen as the regulatory process which keeps the societal level of risk constant. If the level of objective risk decreases, the theory suggests that drivers will shift towards a more risky mode of operation, keeping the number of fatalities at a constant level.

The consequences of this has severe implications for countermeasure implementation programmes, as any improvements in driving conditions, such as alterations to an accident blackspot, will be countered by drivers altering their driving to once again achieve the target level of risk. This implies that all attempts to counter risky driving practices are futile because drivers will simply find other ways to behave in a risky manner. However, as Adams (1990) has pointed out on a recent television programme, if it is indeed pointless to try to prevent drivers partaking in such risky activities, it may be better to introduce remedial measures that decrease the risk to 'second-class' road users (such as cyclists and pedestrians) and therefore to make vehicle drivers responsible for themselves only.

Despite its' intuitive appeal, several authors have criticised risk homeostasis theory. McKenna (1982) cites two examples of intervention, seat-belt usage and highway modification programmes, that have been followed by decreases in accident frequency and severity. Michon (1989) points out that risk homeostasis theory relies on the assumption that the same homeostat (ie. regulatory device) is in operation in all drivers. Haight (1986) has pointed out that this is unlikely and that individuals will adopt different compensation strategies, some being more likely to compensate for fatigue, others poor vehicle maintenance, and so on. In addition, RHT does depend on drivers receiving accurate feedback concerning the societal levels of risk involved in each driving situation. Although it is highly unlikely that drivers do possess accurate knowledge of these objective risks, it may be that their behaviour is governed by their perceived (ie. subjective) risk estimates.

More recently, Janssen and Tenkink (1988) have argued that risk homeostasis cannot be a goal in itself and have suggested that it be considered as more of a by-product of behaviour that has a 'reasonable purpose'. These authors argue that such a purpose would be in the maximization of the overall utility of any particular trip. However, the vast majority of researchers, including Wilde himself, feel that RHT is a weak theory and *possibly* erroneous. This latter point is most eloquently summarized by Haight, who feels that Risk Homeostasis Theory cannot be tested because:

"...the theory does not and cannot specify stable measures of compensation. Thus, if speed, following distances, routing or car choice fail to give desired results, one can further hypothesize that compensation is reflected in failure to keep dental appointments, a tendency to drive with low tyre pressure, etc..." (Haight, 1986, p. 364).

When drivers take risks, there must, by definition, be an element of decision implicated in that choice of behaviour, and this implies that it is no longer meaningful to differentiate between risk theories and decision theories. Therefore, the next section will outline the major principles of behavioural decision theory before discussing some of the most important theories to utilise these principles of decision theory in 'risk' research.

1.6.3 Decision Making and Risk in Drivers

1.6.3.1 Behavioural Decision Theory

The Subjective Expected Utility (SEU) Theory (Edwards, 1954) is probably the most widely-used decision theory and has, according to Wright (1984), four major principles: decidability; transitivity; dominance; and the sure-thing principle. The decidability principle states that if two or more possible outcomes have to be evaluated, the decision maker is able to order the outcomes in terms of how preferable each one is in relation to the others. Transitivity is an ordering principle which states that if outcome A is preferable to outcome B, and also that outcome B is preferable to outcome C, then outcome A will always be preferable to outcome C. The dominance of actions axiom suggests that, if for every possible event, a certain action produces an outcome at least as desirable as those produced by all other actions, and for at least one event produces a more desirable outcome, then the decision maker should always choose that action. Finally, the sure-thing principle simply states that outcomes which are not related to the choice between actions, ie. those which have the same probability of occurrence for all actions, will not influence the selection of an action. Although some of these principles, particularly the sure-thing principle, have received some criticism, it is felt that this is beyond the intended scope of this discussion.

If the relative probabilities of outcomes and events were not considered, the decision maker would have two alternative strategies to adopt in the selection of an action, 'maximax' and 'maximin', based purely on the utility (ie. the desirability) assigned to an action-event combination. The former is an optimistic strategy and requires that the action that may produce the maximum payoff (regardless of the probability involved) is selected. 'Maximin' states that the decision-maker should select the action that maximizes the minimum undesirable outcome. However, each possible outcome for each action has an assigned subjective probability as well as the utility value and the subjective expected utility for each action is a value calculated from the sum of the products of the probability and utility for each combination of action and event. When selecting between actions, the decision maker simply chooses the one which produces the maximum SEU score.

1.6.3.2 Decision Theory Applied to the Study of Driver Decision-Making

Some researchers (eg. Konecni, Ebbesen and Konecni, 1976) have investigated the decision processes of drivers in certain traffic situations, but there have been few studies of driver behaviour using straightforward concepts of decision theory. A study by Mannering, Bottiger and Black (1987) did apply basic decision theory principles to drivers' decision whether or not to drive after drinking. However, there is no evidence of any studies being carried out that have applied SEU theory to drivers' decisions to engage in unsafe practices or not. This is just as well, because there are many problems with this approach.

As Oppe (1988) points out, the decision theory model is often viewed as an economic model in which the decision maker goes along with SEU theory and selects the action with the highest expected utility. This assumes that people are rational and always select the outcome with the highest SEU value, but there is considerable evidence to suggest that people do not always act in such a rational manner. For example, Hendrickx and Vlek (1986) found that people's evaluations of risky activities were highly dependent on the amount of control they believed they possessed in the situations. In addition, Wright (1984) reports that probability estimates tend to be distorted by the ease with which relevant information can be retrieved.

Fuller (1988) notes three additional problems with SEU when attempting to describe human behaviour. Firstly, the theory assumes that human experience is static rather than dynamic, and therefore ignores the fact that alternative choices are often not clearly defined and the pursuit of a goal may require a sequence of events to uncover these alternatives. Another problem noted by Fuller concerns the determination of the utility of an outcome. In many cases, the outcome of a behaviour is not known and problems arise when consideration is given to the methods by which people integrate the utility of such events with the probability of occurrence. Fuller's final problem with SEU theory concerns the additivity of the utility-probability products for each event-action combination in determination of the SEU values. There is evidence (eg. Anderson, 1986) to suggest that this process over-values the SEU and that the overall value may be more accurately reflected by taking averages of the value of each component. In addition, it appears that people have a tendency to place comparatively too much value on outcomes that are almost certain than on ones which are simply probable (Kahneman and Tversky, 1979).

It is clear, therefore, that Subjective Expected Utility Theory is not an appropriate way of describing how people actually make choices in the driving situation, and alternative decision-based theories have been proposed to account for driver decision-making.

1.6.4 Models of Driver Behaviour

1.6.4.1 Zero-Risk Model

The zero-risk model devised by Näätänen and Summala (1976) was notable for suggesting that motivational factors may influence the decisions made by drivers. Perception is seen as an active and selective process governed by experience and motivational factors, and the perceptions are then implicated in the triggering of 'expectancies'. These expectancies are based upon previous perceptions and learning effects, and the concept is therefore similar to that of 'schemata' as used by Neisser (1976) (see Section 1.7). The theory states that drivers learn to predict the behaviours of other road users in much the same way as they learn to predict ballistic trajectories, forming this information into a schema.

Näätänen and Summala posit a control loop that connects perception to expectancy and which controls the switching between automatic (requiring little information processing capacity) and controlled (in which more demand is placed upon the operator) processes. This bears a close resemblance to Rasmussen's (1983) distinction between skill and rule-based activities, and it is assumed that experienced drivers will spend less time performing controlled actions than do novices. The motivational part of the model has two main interactive components: motivations such as reason for journey or affective motivations such as excitement; and the 'fear monitor' (Summala and Näätänen, 1988). Activation of the fear monitor has the effect of automatically inhibiting behaviour, but also elicits the sensation of fear, having a strong negative reinforcement effect which theoretically reduces the probability of the driver subsequently engaging in the behaviour that activated the fear monitor. If fear monitor activation is anticipated, the desired action will not be performed, and therefore the driver will behave in such a way as to avoid sensations of fear, a viewpoint in direct contradiction with that of 'risk homeostasis'. The model posits that:

"...risk control by drivers is based on simple cues and features involved in the situation such as safety margins and normally they neither feel nor estimate risks involved." (Summala and Näätänen, 1988, p. 87).

For example, rather than calculating the probabilities of being able to successfully squeeze into a gap in the traffic, the zero-risk model suggests that drivers only perceive possible gaps and class them as sufficient or insufficient. If feelings of uncertainty or fear are generated, the gap will only be accepted under severe motivational pressure. According to the model, accidents occur as a result of drivers adopting a subjective risk threshold that is too high and prevention schemes should aim to lower the threshold for subjective risk, ie. by reducing the discrepancy between subjective and objective risk estimates.

Fuller (1984) has several criticisms of this model, most notably that the authors appear to be unsure about the role of subjective risk. In some cases, these authors suggest that:

"...subjective risk reactions of road users constitute an important determinant of decision making and behaviour on the road..." (Näätänen and Summala, 1976, p. 189).

whilst also stating that:

"...the majority of road users, most of the time, feel no subjective risk at all." (Näätänen and Summala, 1976, p. 19).

As Fuller points out, if this last statement is true, it is difficult to see how subjective risk reactions can possibly be a major contributory factor to drivers' behaviour.

1.6.4.2 Hierarchical Risk Model

The hierarchical risk model (Bötticher and Van der Molen, 1985) consists of three hierarchically organised levels - the strategic, tactical and operational task levels. The strategic level is the 'highest' order level, and is where decisions about such things as route planning, transport mode and journey purpose are made. The tactical level is where actual traffic manoeuvres, such as crossing a junction or overtaking, are planned. Finally, the lowest order level is the operational level where the manoeuvres decided upon at the tactical level are carried out. This level also accounts for any emergency responses that may be demanded.

The 'physical environment' is the sum total of all the environments of the driver, including details of all possible routes and transport modes at the strategic level, the actual physical environment at the tactical level, and the control mechanisms and course of the vehicle and other vehicles at that moment in time at the operational level. Perception of the physical environment is influenced by the 'Internal Representation' (IR), which concerns the knowledge a driver has about similar situations and possible ways in which the current situation is likely to change, along with knowledge of the driver's own capabilities and potential consequences of interactions with the environment. In some ways, the IR can be thought of as a place where Näätänen and Summala's (1976) concept of fear monitor anticipation, outlined in the previous section, can reside.

The Internal Representation adds meaning to the expectations and perceptions for each situation and the authors distinguish between two forms of expectations: the accident expectations (the subjective probability of an accident using all available information) and other expectations, which refer to the subjective expected probabilities of all possible non-accident alternatives. This can occur at the strategic level (where these considerations refer to the whole trip) and at the tactical level (where they refer to the execution of specific manoeuvres). A similar distinction is made between two types of motivation: safety motivations and other motivations. The former is a subjective measure and can be thought of as a 'disutility', ie. it is a measure of the perceived adversity of the consequences of an accident, and is determined by the extent to which decisions are influenced by accident expectations. Both types of motivation determine the subjective importance of each potential outcome of all possible courses of action. In addition, strategic plan motivation selection at the strategic level affects the form of the strategic plan motivation at the tactical level.

The 'expectancies' and 'motivations' of drivers meet in the 'judgements' part of the model and, once again, the authors distinguish between two types of judgement: risk and other judgements. The former category is where information concerning accident expectations and safety motivations are amalgamated. Strategic plan motivations are integrated with 'other motivations' in the 'other judgements' section. The integration is adaptable to many situations and individual differences concerning the relative weights to attach to expectancies and motivations are possible within the framework, as are alternative integration strategies. The 'decision' component is where decision rules are stored and where they are applied to information supplied from the judgements and an appropriate behaviour is then selected. The decision rules will vary from person to person and alternative rules may be applied by the same person under different circumstances. As Bötticher and Van der Molen (1987) point out, it is probable that the decision rules applied at the strategic and tactical levels will differ as time constraints will usually not be as relevant in the former case.

The final, operational, level is where the manoeuvres are performed and the model suggests that feedback is possible as the progress made by the selected plan of action may be monitored via changes in the environment, possibly resulting in small, unconscious alterations to the execution of the manoeuvre. When faced with a situation perceived as dangerous, emergency behaviour will be selected from what the authors suggest will be a limited repertoire of possible emergency behaviour strategies.

The hierarchical risk model has also been criticised on several counts, most recently by Michon (1989) who feels that Bötticher and Van der Molen have failed to distinguish between the rational level and the process level in their model. Despite the hierarchical structure providing a potentially useful form of task analysis, Michon argues that the processes at work when the intentional point of view is adopted are not necessarily synonymous with those used at the functional level.

1.6.4.3 Threat Avoidance Model

In an attempt to explain the conflict between making progress and avoiding hazards that drivers face, Fuller (1984) devised the Threat Avoidance Model (TAM), a behavioural model of driving. Fuller has borrowed several aspects of learning theory to develop his model, although he does admit that terms such as CS and UCS are used more out of convention than to make comparisons with fundamental aspects of learning theory.

The model states that a future aversive event (UCS - unconditioned stimulus) is signalled by a stimulus (CS_1 - conditioned stimulus). Production of an avoidance response is responsible for the appearance of the new stimulus situation - the neutral stimulus. In a driving situation, the hazardous event may be a potential collision (UCS) with another vehicle (CS_1) pulling out of a junction. The avoidance response of swerving to avoid the vehicle gives way to the new situation (neutral stimulus) of a clear road ahead. Fuller argues that the use of the term 'unconditioned stimulus' is acceptable in this context as the pain and other such negative consequences of an accident can be thought of as unlearned responses.

The next stage of the model accounts for the fact that there are generally conditioned stimuli (CS_2) preceding the stimulus CS_1. In the vast majority of cases, hazards on the road do not appear out of nowhere, and there are recognisable precursors of these hazards, such as approaching a junction, warning road signs, or another vehicle obstructing vision when an overtaking manoeuvre is about to be undertaken. Fuller points out that the relationship between CS_1 and CS_2 is not totally predictable, and there may be situations in which the appearance of CS_2 does not precede the appearance of CS_1. In addition, it is possible that an avoidance action may be carried out in response to CS_2 rather than waiting for CS_1 to appear. This accounts for the possibility of defensive driving practices, as Fuller points out:

"...more risky driving may be characterized as involving delayed avoidance whereas safer driving may be characterized as involving anticipatory avoidance responding." (Fuller, 1988, p. 95/6).

Anticipatory avoidance responses may become associated with certain discriminative or conditioned stimuli, and may become conditioned avoidance responses (CARs). When competing with alternative responses, these CARs are reinforced such that they are followed by rewarding consequences more often than punishing consequences. Fuller (1984) feels that the probability of a driver making such an anticipatory avoidance response is dependent upon the driver's subjective probability of a potential aversive stimulus arising. These anticipatory avoidance responses are reinforced by feedback from previous implementations of the responses.

The probability of an anticipatory response or a non-avoidance response being produced, given the appearance of a discriminative stimulus, is dependent upon the driver's assessment of the subjective probability of expected threat, as well as the reward and punishment possibilities of the response alternatives. In situations in which no discriminative stimulus is perceived, and in which no threat is realised, the expectation, that there actually is no threat, will be correct. However, when the threat is realised, implying that some error was made, a delayed avoidance response is required if an accident is to be avoided.

In situations for which the driver fails to make an anticipatory avoidance response to a discriminative stimulus, the model dictates that an increase in the level of arousal perceived by the driver may result. This may become aversive and a delayed avoidance response elicited. Additionally, particularly in situations in which the driver has a high subjective expected threat level, Fuller suggests that drivers may begin to become aware of the sensation of risk. Indeed, Taylor (1981) has stated that, as well as being a component of risk, high arousal may also serve to induce such sensations. The model suggests that the implementation of delayed avoidance responses under circumstances in which aversive high arousal level are present will be rewarded by a reduction in that arousal, and hence by a reduction in the sensations of tension and anxiety. Fuller (op.cit.) proposes that there may be individual differences in the use of avoidance responses, some drivers preferring anticipatory responses, others delayed responses. Additionally, drivers may adopt different responses in different situations.

While Michon (1989) finds many aspects of Fuller's threat avoidance model appealing, he does feel that the theory is unable to comfortably deal with situations which are more complicated than the standard threat-avoidance reaction. For example, many situations occur in which a driver must concentrate on the events in the immediate vicinity (such as monitoring the vehicle in front) whilst meanwhile looking for the required exit road. This kind of 'embedded' serial behaviour is difficult to explain in terms of the model, as Michon says:

"...the word 'meanwhile' does not exist in the vocabulary of behaviourism, however rich its meaning in everyday life." (Michon, 1989, p. 346).

1.6.5 Implications of Cognitive Perspectives for Driver Training and the Current Research

1.6.5.1 Implications for Driver Training

Several models of driver behaviour have been outlined in this section, and it is felt that the contribution that each of them may be able to driver training should be discussed. The Risk Homeostasis Theory attributed to Wilde (1982) suggests that risky behaviours by drivers will be most effectively reduced if the perceived danger of the road environment is increased. If drivers perceive any particular driving situation as risky, the theory dictates that they will adjust their driving style to avoid more risky activities, thus reducing the number of accidents. The problems with RHT have already been noted in Section 1.6.2.4, and it is argued that making changes to the driving environment to increase its risk level by providing drivers with more opportunities to make errors is more likely to produce an effect in direct opposition to the desired effect. Whatever the limitations of RHT, it is clear that it has little to offer to the development of driver training programmes. The theory implies that drivers are responding to their subjective risk estimates at a largely subconscious level, and, if RHT proved to be an accurate model of how drivers perceive risk, it seems unlikely that drivers could be trained to ignore their risk estimates.

According to the Zero-Risk model of Näätänen and Summala (1976) (see Section 1.6.4.1), drivers' undesirable behaviours may best be countered by reducing the discrepancy between subjective and objective risk assessments. This requires ensuring that drivers have extremely well-developed 'fear monitors', and, according to this model, it would appear that training programmes would be most effectively employed in the development of these monitors. In a similar way, the Hierarchical Risk model of Bötticher and Van der Molen (1985) (see Section 1.6.4.2) suggests that an increased understanding of the ways in which the 'Internal Representation' part of their model is structured may help to understand why drivers make errors.

Fuller (1988) notes that, according to his Threat Avoidance Model (Section 1.6.4.3), novice drivers must learn about the relationships between the conditioned stimulus, preconditions (CS_1 and CS_2 respectively) and also the consequences of the actions produced to enable them to learn how effective avoidance responses are structured. Fuller's model dictates that driving behaviour is governed by the consequences of behaviour, the relationships between which remain constant under certain stimulus conditions, these conditions becoming discriminative stimuli for the relationship between 'behaviour' and 'consequence'. The implications of this for driver training are that drivers must be provided with knowledge of as wide a range of such behaviour-consequence relationships as possible, but prior to this it is necessary to understand how individuals represent particular situations to themselves.

1.6.5.2 Implications for the Current Research

Despite the obvious differences between each of the models discussed in Section 1.6.4, one of the most striking factors to emerge from this discussion has been the similarity between, arguably, the core concepts of each theory. The structures of Näätänen and Summala's 'Fear Monitor', Bötticher and Van der Molen's 'Internal Representation' component and Fuller's CS_1-CS_2 relationship have many similarities to each other in that all are concerned with expectancies and perception and are modifiable by experience. These ideas are similar to those connected with the concept of 'schemata', and it is felt that further investigation into this topic may be appropriate at this stage. However, it is also worth noting that these concepts also have correspondence with the central notion of Aasman and Michon's (1989) 'SOAR' (State Operator And Result) problem-solving approach to driving - namely the 'heuristics', or problem-solving strategies. The theory states that the more complex a driver's heuristic knowledge, the more efficient and experienced that driver can be said to be.

This section has mainly focused upon cognitive and information-processing approaches to the study of driver behaviour. However, it is has become clear that some form of central concept is, in essence, shared by the theories discussed in this section, and the next section of this chapter will be devoted to the discussion of schemata and the ways in which use of this idea may be able to contribute to the current research.

1.7: SCHEMATA & THEIR APPLICATION TO THE STUDY OF DRIVER BEHAVIOUR

1.7.1 Definition of a Schema and Early Theoretical Approaches

The term 'schema' was first used by Bartlett (1932, cited by Neisser, 1976) to describe a central cognitive structure in perception, although it has also been used by a number of other authors (eg. Piaget, 1952, cited by Neisser, 1976) to describe other unrelated phenomena. The execution of all forms of skilled activity depends upon many factors, including: the current state of affairs; previous events; and the plans and expectations of the performer.

One of the main points of this process is the suggestion that, whilst it has no direct effect upon the environment, the perception of a phenomenon changes the perceiver, as does the action. Therefore, the perceiver can be said to have arrived at his or her current state by virtue of such perceptions and, as the opportunities for perceiving and acting are truly unique for each individual, no two people will possess exactly the same set of schema.

Bartlett's (op. cit.) work on recall and recognition of complex information suggested that subjects tended to reduce that information by abbreviation, simplification and distortion of context. "Effort after meaning" was the phrase used by Bartlett to summarise the process of remembering, which was seen as a dynamic activity involving an active process of reconstruction. In the words of Hamilton:

"Complex stimulation with a long and involved story containing unfamiliar concepts and words, or with pictorial material containing much detail, is assimilated to existing knowledge, concepts, and schemata." (Hamilton, 1983, p. 61).

This assimilation of new information with old constitutes the perceiver's knowledge, attitude and subjective interpretation of the total environment and accompanying stimuli connected with the schema.

Bartlett defined a schema as:

"...a dynamically flexible organisation of past events, their characteristics, contexts, and implications, with a large capacity for further modification by new events." (Bartlett, 1932, cited by Hamilton, 1983, p. 61).

Alternative definitions have been offered by other authors, but have added little to Bartlett's original. For example, Neisser elaborated upon the Bartlett definition by stating that a schema is:

"...that portion of the entire perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema accepts information as it becomes available at sensory surfaces and is changed by that information; it directs movements and exploratory activities that make more information available, by which it is further modified." (Neisser, 1976, p. 53).

Neisser compares the function of a schema to that of a 'format' in the realm of computers in that these are responsible for specifying the type of information required to allow for coherent interpretation. Information which does not comply with the rules dictated by the format will be ignored or lead to erroneous results. However, it should be noted that the schemata need not be restricting as they are able to operate at any level of generality. Neisser also develops the idea of Miller, Galanter and Pribram (1960, cited by Neisser, 1976) by pointing out that schemata can act as 'plans' for discovering the nature of objects and events and therefore for obtaining more information to add to the format. The main difference between schemata and such plans lies in the fact that the former includes the method of execution for the plan, not simply the plan itself. Schemata are therefore able to dictate how the perceiver should act in any given situation by, for example, directing movements of the head to optimise the amount of information received. It is suggested that schemata are also responsible for selection of information, and Neisser suggests that information may only be picked up if there is a developing format able to assimilate the new information. Clearly, this suggests that a new schema must be formed from elements of existing schemata and thereby implying that the whole network of schemata is highly interconnected and, by necessity, highly complex.

One of the main questions concerning schemata is their process of development, as the formation of a new schema is reliant upon information from existing schema. According to this model, a newly-born child must have basic schemata with which to develop subsequent schema. Indeed, Neisser credits newly-born children with a basic knowledge about how to discover things about their environment and how to organise the information so as to enable further discoveries to be made.

Some researchers have used the concept of schemata to investigate topics in the general area of social psychology. For example, Levine and Murphy (1943, cited by Hamilton, 1983) looked at the effect of pre-existing political attitudes on the recall of both pro- and anti-communist passages of prose. The stimulus material and existing beliefs were shown to interact, affecting the extent and content of recall. In addition, Allport and Postman (1948, cited by Hamilton, 1983) carried out a study which revealed that visual memory could be affected by prejudiced ethnic beliefs to a striking degree. Despite these early studies, it remains unclear as to how to apply, and derive precise conclusions from, Bartlett's original concept. In fact, some authors (eg. Baddeley, 1976) argue that the schemata concept is not useful because they feel that it is untestable.

It is possible that such misgivings have resulted from the fact that, until recently, the idea of schemata had not been incorporated into a applicable model. In the next section, some attempts to do this will be described.

1.7.2 Models Incorporating the Notion of Schemata

1.7.2.1 Norman's Activation-Trigger-Schema Framework

Figure 1.2 (below) shows Norman's (1981) Activation-Trigger-Schema (ATS) error classification system, designed to support theories concerning complex cognitive functioning, such as that discussed by Norman and Shallice (1980, cited by Norman, 1981).

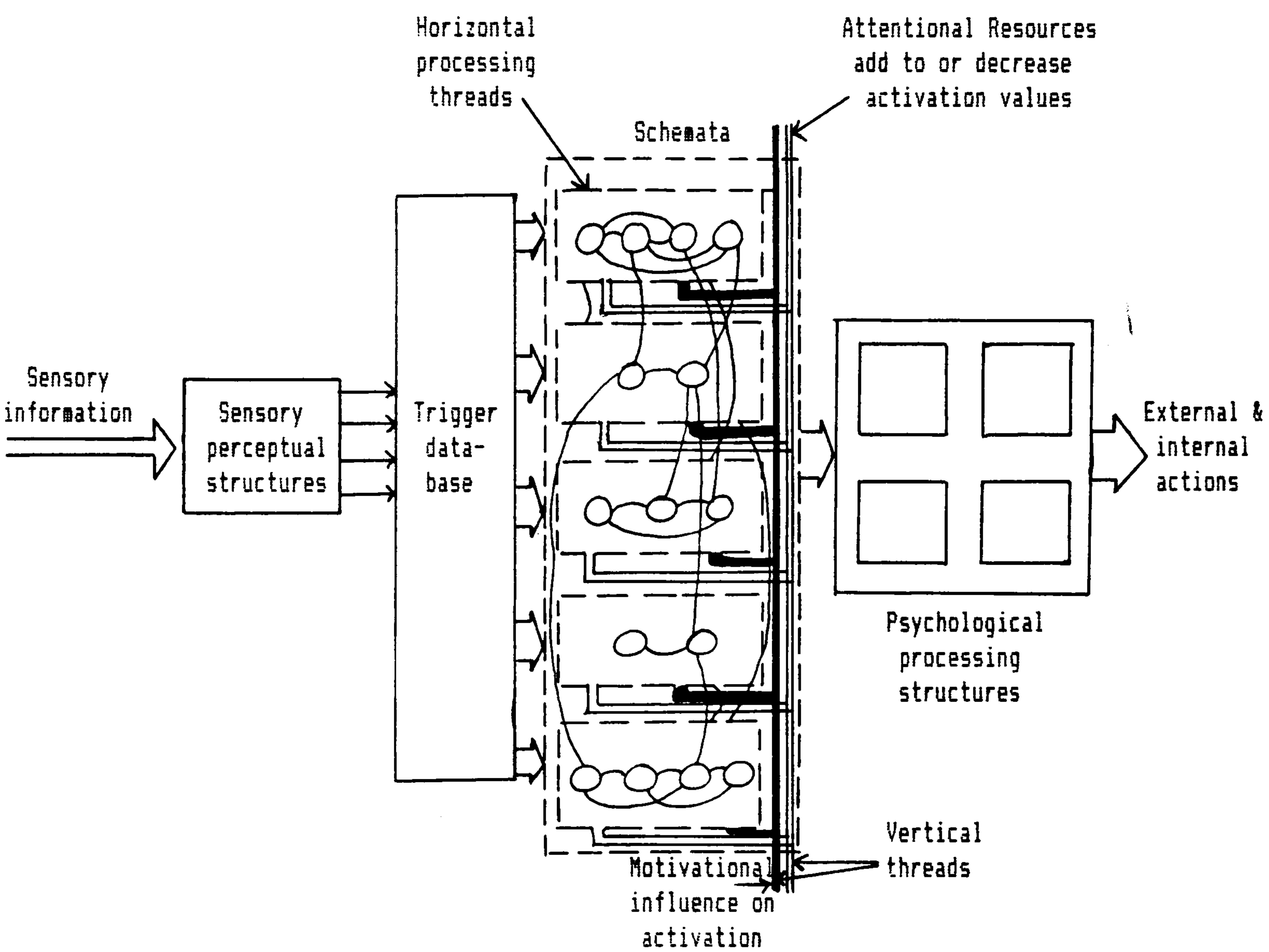

Figure 1.2: Norman's Activation-Trigger-Schema Framework (from Norman, 1981)

The core concept of Norman's theory is an organised body of knowledge, the schema, which is able exert direct control over motor functioning. A triggering mechanism is associated with each schema so that when a particular situation arises, the trigger is able to activate its' schema, which in turn activates a set of actions. Each schema has an activation level which details the extent of its' level of activation at all times. This level will be very low when a schema is not in use or is unlikely to be used, increasing as the schema is activated. Once activated, the schema engages "psychological processing structures" (Norman and Shallice, op.cit.) which activate the action from the output of that schema. The theory states that many such activation processes can occur simultaneously, provided that no two psychological processing structures are required by the same schema. If this does occur, the vertical threads included in the model are so placed to account for these situations, and operate on the activation value of a schema rather than on a schema itself. Such a contingency allows for situations in which it is preferable to override a familiar (ie. frequently-triggered) schema and perform a more important action. A final component, called the Contention Scheduling Mechanism, evaluates the contributions of the triggers, horizontal and vertical threads and selects the most appropriate schema for the prevailing circumstances.

The ATS framework allows for errors falling into three main categories, and these show similarities to those suggested by Reason (1987) and Rasmussen (1983), introduced in Section 1.5.2. The three main error categories are: those resulting from failures of intention formation; those from faulty (ie. inappropriate or incomplete) activation of schema; and finally those resulting from faulty triggering of schema, either by triggering at an inappropriate time or not reaching the required activation level. As Groeger and Brown (unpublished) point out, Norman's ATS framework has advantages over other models, such as that proposed by Reason in the previous section, in that, in addition to provision of a reasonably comprehensive error classification system, it is also able to provide a plausible theoretical background allowing for factors such as arousal, motivation, inattention and skill development.

However, other researchers have highlighted some problems with this model. For example, MacKay (1987) argues that priming, as well as activation level, must have a role to play in the employment of schemata. The selection of zero as the resting activation level of a schema has also received criticism from MacKay, and, although it should be stated that the model would appear to be suitably flexible to allow for the accommodation of such slight differences of approach, this may not be so. Groeger and Brown (op. cit.) feel that these differences may produce alternative predictions concerning behavioural control and therefore to interpretations of the causes of errors.

Norman's Activation-Trigger-Schema model certainly places more emphasis on the cognitive processes underlying the formation of errors than those outlined in Section 1.5.2. However, in terms of the ATS model, before the causal factors behind errors can be understood, the formation of particular schema and their associated triggers and resulting actions must be subjected to investigation. Prior to discussing the contribution that Norman's framework may be able to make to the current research, another model incorporating the concept of schema will be discussed.

1.7.2.2 Hogarth's Conceptual Model of Judgement

Hogarth's Conceptual Model of Judgement (1987) (see Figure 1.3, below) was developed from his concern that the potential consequences of errors of judgement are far greater today than ever before. For example, the degree of complexity involved in operating an atomic power station and the accompanying increase in the number of opportunities for error-making, coupled with the potentially devastating consequences of an error, may be considered to offer more of a threat to more people than methods of power generation methods preceding nuclear power.

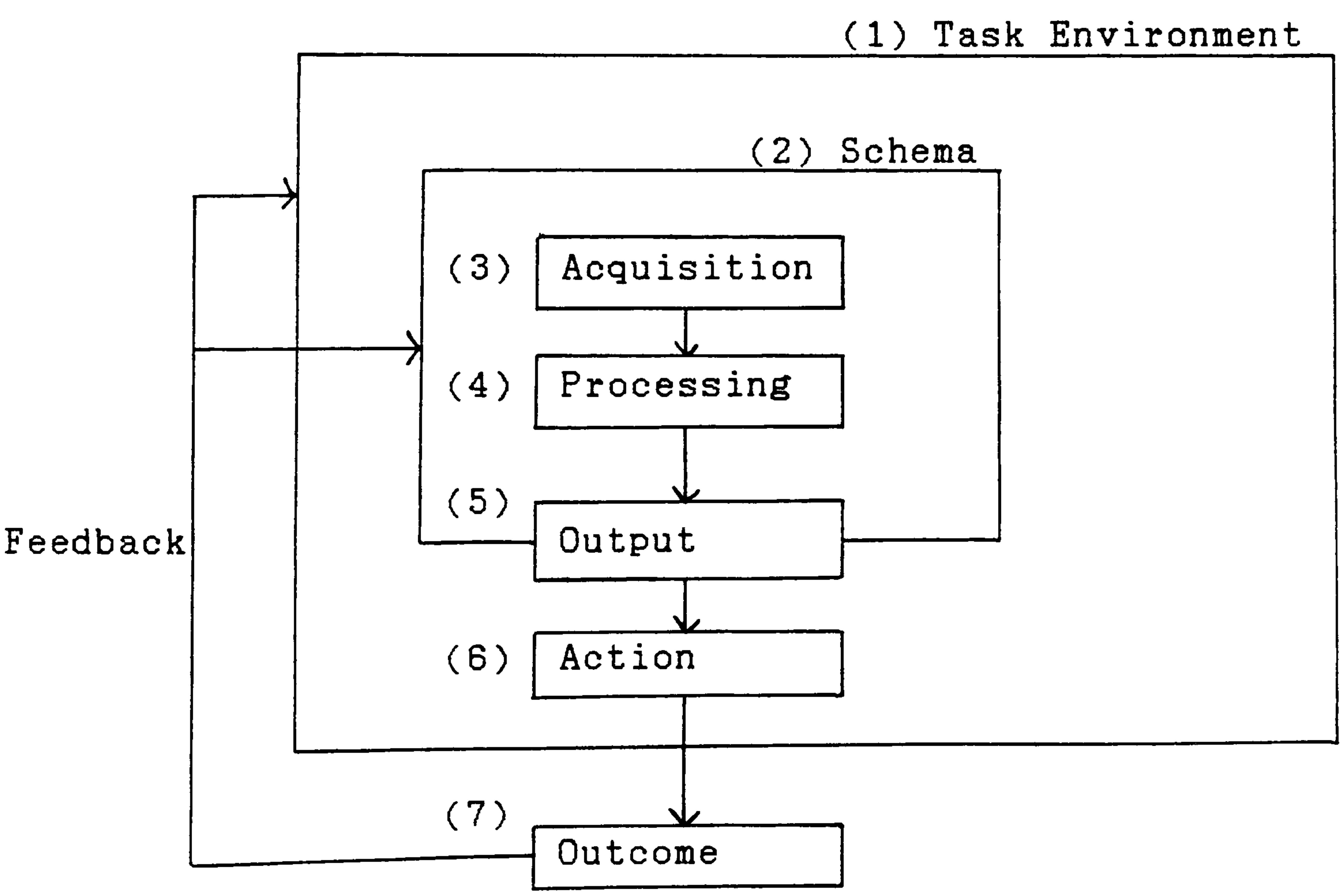

Figure 1.3: Hogarth's Conceptual Model of Judgement (from Hogarth, 1987)

The overall framework combines elements of many aspects of decision theory, and catalogues the types of biases of judgement to which human beings are prone. This takes into account the stages of information processing during which these biases may occur; the characteristics of certain situations which may produce biased responses; and the nature of the schema in which the errors operate. It follows, therefore, that the accuracy of a person's judgements about a particular situation (or the degree of realism of their schemata) dictates the likelihood of judgemental bias occurring.

Judgement is said to occur within the *task environment*, contained within which is the *schema* for the situation. Hogarth defined the schema in this sense as:

"...the person's beliefs concerning the task environment and his or her representation of it; that is, how he or she perceives the judgemental task ... The schema is created both by the person's memory and characteristics of the judgemental task." (Hogarth, 1987, p. 157/8).

The information processing component is sub-divided into three categories and constitute the stages leading to judgement-making. The first of these components, *acquisition*, refers to all sources of information from memory and the environment and the selection of bits of information to be used will be dictated by the schema. The second component, *processing*, is simply where that information is processed. The result of the information processing is the *output*, which contains the judgement about how to deal with the situation. This output occurs at the interface of the task environment and the schema and it is the output that represents the schema's effect on the task environment. Hogarth points out that this output will often be indistinguishable to the *action* in the eyes of a third party. The action is the external manifestation of the schema, and operates within the task environment. The final component, the *outcome*, refers to the situation that has resulted from this process. The outcomes provide feedback which may modify the schema, and may also affect the task environment. It should be noted that each of the three major elements in the system, the person, the action and the environment, are all affected by each other and the model is seen as highly interactive.

To use a driving example, a driver who is engaged in the activity of approaching a junction (the task environment) will possess a schema of that activity which has been compiled from all previous attempts to approach a junction. However, it is argued that it is not simply personal experience that adds to or alters the schema as there must be scope for the experiences of others to contribute. The information that is acquired consists of, amongst other things, the relative positions of all other vehicles in the immediate vicinity. These relative positions and movements are processed and an outcome, or decision, is made. For example, the driver may have to decide whether pulling straight out onto the junction is going to result in a collision with a vehicle approaching from another direction, or whether entry onto the junction will be trouble free. The movements of other vehicles (within the task environment), and memories of previous similar encounters, will affect the judgement that is made. The driver may decide to stop at the 'Give Way' line (ie. the action), the outcome of which is that no collision occurred. This has an obvious affect on the environment, and will contribute to the driver's general schema concerned with approaching junctions.

Judgemental biases may occur at any of the stages of information processing described above. One of the major problems lies in the fact that humans have relatively limited information processing capacities, and this can have several consequences. As previously stated, the perception of information may be selective, missing out on much of the available information. If the schema is inaccurate or incomplete, the bits of information that are selected may not be the most appropriate for the situation encountered. People also have a tendency to process information in a predominantly sequential manner, as well as to simplify judgemental tasks and thereby reduce intellectual effort. Finally, information processing is also limited by memory capacity.

The sources of bias are seen to occur at one, or more, of four stages. The first stage, in which the information is acquired, is largely dependent upon the salience of information. People's selection of information to be processed may be biased by expectations and prior knowledge contained within the schema. The more salient a bit of information, the more it is likely to be judged as being important and frequently occurring and the more easily will associated information be recalled. In other words, people tend to perceive what they expect to perceive, disregarding or not perceiving information that is not consistent with their prior assumptions (eg. Bruner and Postman, 1949, cited by Hogarth, 1987). There is also the related phenomena of frequency biases, whereby the perceiver focuses upon the absolute frequency of a situation rather than the more useful relative frequency, which takes account of the number of times in which the situation did not occur.

The second stage at which bias may occur is during the processing of information, in which the person makes a decision or invokes an information-processing rule. For example, the individual may choose to adopt a judgement that worked well in a previous situation. This choice may be made habitually, and there need not be any guarantee that the same judgement will be relevant to the new situation. However, Hogarth states that the majority of processing biases result from three basic sources: task variables; unwillingness to expend mental effort; and inconsistency in application of judgemental rules. Task variables may include such features as time restraints or simply the amount of information available. It is also argued that people tend to make judgements by processes which reduce the amount of mental effort that needs to be made, and therefore underestimate the degree of variability of circumstances in the environment. In these cases, the person is unwilling to make the effort to apply elements of processing strategies from one task to other tasks for which they may be appropriate. Hogarth finally concludes the sources of processing biases by pointing out that, in general, individuals do not appear capable of applying the same judgemental rule over a series of cases. In other words, they are often unable to apply a strategy that has been shown to be effective previously in very similar situations.

The third area of bias is contained within the output processes, whereby a particular bias is governed by the chosen method of stating the problem. For example, people's estimates of probabilities have been shown to vary according to the alternative types of responses that were requested (Hogarth, 1975, cited by Hogarth, 1987).

The final stage concerns the feedback processes, which may be considered to be one of the most important stages since feedback allows one to to learn from experience. Without feedback, learning is impossible. One of the classic examples that falls into this class is the confusion between chance occurrences and causal relationships. As Hogarth (1987) points out, chance is an artificial concept, as all outcomes must have some causal factors. However, chance refers to situations in which an unidentifiable circumstance, or set of circumstances, causes the outcome. This misinterpretation can therefore be seen as an 'erroneous causal attribution'. One example of this kind of phenomenon was described by Langer (1975) as the 'illusion of control', in which the outcome of a particular activity is thought to be under control by the participant whereas, in reality, no such control exists. The tendency is therefore for people to attribute success to skill (ie. controlled events) and failure to bad luck (chance events). Discussing Langer's theory, Hogarth concludes:

"This bias clearly has important implications for decision makers when considering their track-records of past successes and failures, as well as their efforts to make plans for the future." (Hogarth, 1987, p. 164).

Hogarth distinguishes between those biases which are attributable to the schema from those which are attributable to the situation itself. The conditions falling into the former category are those which are concerned with the method by which an individual approaches a problem, rather than more objective factors related to the situation itself. The three major dimensions of a schema-generated bias concern the veridicality of the schema (ie. the extent to which the schema represents 'reality'); the stability of the schema (ie. how variable it is); and the generality of the schema (ie. the range of phenomena that the schema covers). A higher probability of bias occurs in situations in which the veridicality, stability or generality of the schema is low. It should be noted that these dimensions are thought to be inter-related, and the state of one dimension may affect the state of one or both of the other dimensions.

The main types of situation-generated bias are ones with a high degree of complexity; a high degree of procedural uncertainty; and which induce a high degree of stress. A fourth type of condition, psychological regret, relates to the extent to which a decision error has an affect upon the decision makers' feelings.

This section has aimed to provide an outline of the model of judgemental bias devised by Hogarth. In the next section, the ways in which the idea of schemata and the models devised by Norman and Hogarth may be applied to the study of driver behaviour are discussed.

1.7.3 The Concept of Schemata in Driver Behaviour Research

In the previous section it was noted that the ways in which any task requires the performer to select, process and act upon information does much to dictate the level of success achieved by that performer. The notion of schemata, when used in the same context as that suggested by both Norman (1981) and Hogarth (1987), would appear to play a significant role in the determination of how performers carry out these information processing activities.

Driving is just one example of a complex activity, with the driver having to process information from many sources in order to be successful (in terms of accident avoidance) at the task. By examining the structure and formation of certain schema related to junction negotiation, it is felt that key areas of deficiency may be highlighted. Consequently, the study of such schema will suggest methods by which existing schema may be subjected to change and how improved training may, theoretically, ensure that future drivers do not develop inappropriate schemata in the first place. For example, contained within a particular driver's schema concerned with approaching a junction will be information relating to how young male drivers negotiate that type of junction. This schema will be formed as a result of previous experience of the behaviour of young male drivers encountered under the same, or similar, circumstances. However, the theory states that it is likely that this information will be augmented with that from other sources, such as attitudes of the relevant peer group or media reports, as well as factors resulting from age and experience. It is suggested that this type of specific schema will form part of a more general schema about junction negotiation. In other words, the general schema may contain a 'note' to pay special attention to any young male drivers encountered. If the information within the specific schema suggests that a young male driver is more likely to treat the negotiation of the junction with more neglect than an older driver, it follows that the driver in question should adopt a more cautious stance if a younger driver is encountered.

The ATS model devised by Norman (op. cit.) offered a plausible cognitive framework for errors, despite some criticisms about the detailed structure of the model. The notion of such a model has many appealing facets. As Groeger (1988) points out, a model which stores previously-utilised operations every time they are brought into action does not make sense in economic or 'architectural' (ie. structural) terms, and it would seem to be far more efficient to have a model which has a storage facility for commonly-used actions, the operation of which is governed by activation levels, as well as allowing for novel actions to be stored within the system. Actions that have common factors, or which are performed simultaneously, may be combined into schemata. The theory also implies that a pre-stored, commonly-used action will require less from an operator's resource pool than an action which occurs less frequently or has never previously been used. In Rasmussen's (1983) terms, the commonly-used actions will be carried out with more skill-based behaviour than rule-based, but increased experience means that knowledge-based components can be drawn upon when necessary.

Hogarth's (1987) model has many similarities to Norman's ATS framework in that it provides a model for error-making within a cognitive framework using a central concept of schemata. However, it does not offer the same level of complexity as the ATS model, concentrating less upon information processing aspects of errors and more upon attempts to explain circumstances under which bias, and hence errors, may occur. Despite this, it is argued that these models may both have something to contribute to the central theme of this research: notably that drivers' errors at junctions can only be fully understood by taking into account aspects of the cognitive and social environment in which drivers operate, and that the study of aspects and development of schemata is the most appropriate way to approach this problem.

The final section of this introductory chapter provides a summary of the main points from each of the main sections, before outlining the specific direction for this study.

1.8: CHAPTER SUMMARY & THEORETICAL BACKGROUND TO THE CURRENT RESEARCH

1.8.1 Summary of Main Points from Chapter 1

Before the main objectives of the present study can be mapped out, it is felt that a brief summary of the main points from this literature review is warranted. The first section described the nature of the problem, detailing the number of accidents occurring in Great Britain in recent years along with some details of the type and severity of the accidents. Junctions were found to be a major source of accidents, and after a brief discussion about the use of junctions in the road network, it was decided that the nature of junction accidents should be the main area of investigation. The next section looked at some of the methods road safety researchers have used to investigate road accidents, this being followed by a section which looked into the various ways in which road user behaviour may be influenced. Although it was felt that, in certain circumstances, enforcement and engineering approaches may be able to tackle some of the problems, it was concluded that there are more complex factors at work and that the educational approach was more likely to produce long-term changes in driver behaviours. Therefore Section 1.4 reviewed current approaches to driver training and the use of additional training programmes. It was concluded that the relative failure of such training programmes was mainly due to the fact that, as yet, there is an incomplete understanding of the driving task and the ways in which drivers view their own driving and that of others.

Following on from the discussion of driver training, Section 1.5 outlined current approaches to error analysis in an attempt to improve systems for classifying and understanding the types of errors made by drivers. The work of Hudson and Reason (unpublished) has outlined the need for a greater understanding of the circumstances under which errors become more likely to appear and the GEMS model devised by Reason (1987) contributed much to a further understanding the failures in the system and the production of errors. To date, the main problem of these approaches has been a lack of a cognitive structure that will enable the models to be applied to the improvement of training programmes.

The next section began by focusing upon work that has incorporated information processing models to the study of driver error, before discussing the many approaches to the study of risk and risk perception. Decision-theoretical approaches have become intertwined with many risk models, and some of the driving models that incorporated these concepts were discussed. The main point that emerged from this discussion was the apparent similarity of certain aspects of many of these models. In particular, it was argued that they all incorporated a concept similar to that of 'schemata' and this topic formed the discussion for the final main section of this introduction. It was concluded that the underlying processes which contribute to driver errors should be subjected to investigation, and that the approach should focus upon an integration of cognitive and social components of the driving task, using the concept of junction driving schema as a focal point.

1.8.2 Theoretical Background for the Current Research

The preceding sections suggest that the primary goal for this research should be to investigate, and develop a further understanding of, the schema implicated in accidents at junctions. Although many alternative theories have attempted to model driver behaviour and the errors produced, none of them appear to have been backed up with empirical data to support, or to challenge, the theories. Many theories include something akin to the concept of schemata, but no research has been conducted that sets out to look at the nature of these schemata, their formation, development, organisation, adaptability to novel situations and manifestation. The implications for this development of schemata, and particularly the ways in which inappropriate schema are produced, should be concerned mainly with reviewing the current methods of driver training in respect of the results, and suggesting modifications or alternative training strategies that may be adopted.

Research in this area is still at an exploratory stage and it is argued that it would be counter-productive to concentrate upon all aspects of the development of schemata at this stage. In the view of Michon (1980), it is important to take into account aspects of drivers' perceptions and attitudes towards their own, and others', driving as well as how these are connected with observable behaviours. Therefore, it is intended that the current study will concentrate upon investigating aspects of schema that can be derived from drivers' attitudes, beliefs and perceptions of their own, and others', driving. Unfortunately, due to the highly complex and interconnected nature of schemata, it is unlikely that it will ever be able to fully 'map out' any schema, particularly given that every individual, by definition, will possess unique schemata resulting from their unique set of driving experiences. Despite this, it is felt that there may be more generalisable components (or even sub-schema) that may be common to certain classes of drivers, and it is the primary goal of this research to uncover any such components.

However, before these concepts can be put into context, it is argued that a more thorough understanding of the types of errors made by drivers at junctions, and the factors implicated in the production of those errors, must be developed. This implies that the issues outlined here would be most appropriately investigated by adoption of a two-stage study. The first, a more objective approach looking into the nature of actual errors occurring at junctions, the second a subjective account of driving practices at junctions, using information derived from the first study, and aimed at producing a more thorough understanding of the underlying processes behind those errors, and hence uncovering schema concerned with driving at junctions. The next chapter will concentrate upon issues that are relevant to the study of road-user errors at junctions.

CHAPTER 2:

INTRODUCTION TO STUDY 1

2.0: OVERVIEW

The ultimate objective of this research is to investigate the errors made at junctions and subsequently to suggest methods in which those errors may be prevented. The previous chapter ended with the conclusion that more information about the types of errors that occur at junctions was needed, and therefore it seems logical that this initial study should aim to do just this. In other words, the nature of the accidents themselves, as well as the nature of near-miss and non-accident driving in the same circumstances, must be analysed before the underlying accident-causation factors can be determined. However, prior to that, it is felt that a brief review of some of the main issues relevant to driving at junctions is warranted. Section 2.1 therefore summarises the literature on sight distance, close following and gap acceptance issues.

The level of information contained within accident records is generally insufficient to meet these demands (see Section 1.2.1) and clearly an alternative method had to be sought. Section 2.2 briefly discusses some of the approaches that have been used by researchers in the past. Section 2.3 provides a more extensive summary of the main points concerned with the most used approach: the traffic conflicts technique. There are several different ways in which information of this type can be obtained, and it is felt that the arguments for adopting the major techniques used in Study 1 should be aired at this stage, therefore Section 2.4 outlines the major methodological considerations for this initial study. Finally, Section 2.5 provides a brief summary of the main points from this chapter prior to discussing the applicability of these points to this first phase of the research.

2.1: ISSUES RELEVANT TO DRIVING AT JUNCTIONS

2.1.1 Close-Following Behaviour

Following distances have been found to be implicated in a relatively large proportion of accidents. For example, a review by Sabey (1973) discovered that 13% of the sample of accidents investigated were of this nature. Clearly, there appears to be some discrepancy between what are actually safe following distances those which drivers perceive to be safe.

It has been shown (eg. Rockwell, 1972, cited by Colbourn, Brown and Copeman, 1978) that drivers generally aim to maintain a following distance of two seconds, slowing down if the gap time decreases. In normal car-following situations, the field study revealed the mean vehicle separation time as being in the region of 3-4 seconds. A simulation study performed by Colbourn, Brown and Copeman (op. cit.) confirmed that drivers tended to stick to this two-second gap, even though they had no feedback concerning their speed, and could also bring their vehicles to a halt within this margin.

Whilst this may be true in such a simulation and presumably in the majority of instances on the road (otherwise there would be many more rear-end shunt accidents than there appear to be), the accident records reveal that there are still many occasions when drivers are not able to pull up in time. Colbourn et al. argued that this stems from some drivers having difficulty in evaluating risk and hazard rather than being a product of inadequate perceptual abilities. It is suggested that a lack of attention to the situation, presumably not a feature of Colbourn et al.'s (op. cit.) study due to its obvious (to the participants) status as an 'experiment', may be another factor that contributes to such incidents. It should be noted that, although these researchers controlled for experience, only eighteen subjects were used, all of them male. Despite these limitations, it seems that there may be more to the issue of rear-end shunt incidents than following too closely for the speed selected.

With respect to close-following behaviour on the approaches to junctions, little research appears to have been carried out. However, motorway driving also displays its' fair share of close-following behaviour, and it is suggested that there may be some parallels with junction approach behaviour. Postans and Wilson (1983) found that over 20% of 2000 close-following incidents on the M1 motorway involved gap times of less than half a second. Given the speeds with which vehicles travel on such stretches of road, this is clearly a highly dangerous practice. A similar study by Edwards (1987) found that 47% of all drivers studied adopted gap times of less than two seconds. Drivers of all vehicle types were seen to display the same amount of close-following, although this was most common when the vehicle pairs were of the same type (eg. a car following a car). However, there does not appear to be any research which has looked into the reasons for this high level of close-following in such a potentially dangerous situation.

2.1.2 Gap Acceptance Criteria

As a driver approaches a 'Give Way' or 'Stop' line at a junction, the decision whether or not there is sufficient space to enter that junction and merge with the traffic without endangering any of the participants must be made. The elapsed time between any two vehicles on the major road is referred to as the gap time available to the driver waiting to enter the junction and travelling in the same direction. Tsongos and Weiner (1969) differentiate gap time from 'lag time' which records the elapsed time between the arrival of the minor road vehicle at the junction and the arrival of the next vehicle travelling along the main road at the point of the intersection. These researchers investigated the gap and lag acceptance criteria of drivers at a junction during daylight and night-time conditions. It was found that, at night, drivers would accept gaps or lags of between 3 and 10 seconds, with a mean of 5.6 seconds. During daylight, the criteria shifted slightly to between 2 and 9 seconds, with a mean acceptance time of 5.4 seconds.

An alternative study utilising the concept of gap acceptance was carried out by McDowell, Wennell, Storr and Darzentas (1983). Treating the concepts of gap and lag acceptance as synonymous, these researchers found that it was possible to use these measures as surrogates for accident counts. A ranking of priority-controlled T-junctions in order of the gap acceptance behaviour of drivers was found to closely correspond with a ranking performed using the accident histories of the same junctions over a five-year period. It was also found that female drivers accepted significantly larger gaps than male drivers, this being interpreted as implying that females are more cautious when entering junctions. An earlier study by Darzentas, McDowell and Cooper (1980) had shown that younger drivers of both sexes accepted shorter gaps than older drivers, but were found to be more consistent over time.

Several other factors have been linked to gap acceptance behaviour. For example, Ebbesen and Haney (1973) discovered that drivers who had to wait in a queue of traffic prior to entering a junction accepted shorter gaps than did those who had not been required to wait. However, the presence of a vehicle behind or to one side was not found to have an effect. Certainly, the evidence suggests that there are individual differences in gap acceptance criteria and this has clear implications for the study of driving at junctions. Furthermore, it is hypothesized that may be a main causal factor in a number of accidents and this matter should receive attention.

2.1.3 Sight Distances

A topic that is closely related to gap acceptance and related criteria is the sight distance available to drivers at junctions. According to the Ministry of Transport in 1968, drivers approaching a junction along a minor road should have:

"...unobstructed visibility to the left and right along the main road so that he may judge when an adequate gap occurs in the traffic flow for his vehicle to turn into the main road." (Ministry of Transport, 1968, p. 17).

Obviously, in situations where the visibility distance available to such drivers is limited, the decision to enter the junction on the basis of there being a suitably large gap cannot be made with any great degree of confidence. Ideally, the layout of a junction should be such that an approaching driver has a clear view of activity on all other connecting roads from a distance at least as far back as that necessary to comfortably decelerate and stop at the intersection. Naturally, this is highly dependent upon approach speeds and much of the research investigating sight distances has focused upon this issue.

For example, Robertson, McLean and Ryan (1966, cited by Lovegrove, 1978) studied drivers' approach speeds at junctions with restricted sight distances. They showed that drivers frequently exceeded the calculated maximum safe approach speed for which a vehicle could not be stopped at the intersection to avoid collision with a vehicle that may be just out of sight in the right-hand field of vision. However, the driver always has the option of compensating for this by reducing speed and applying more caution in the vicinity of the 'Give Way' line, a phenomenon found by Glanville (1954). The reasons why such behaviours do not always appear to be applied have not been subjected to thorough investigation and it is suggested that the current study may be able to shed some light on this matter. However, Cumming (1972, cited by Lovegrove, 1978) did suggest that many drivers may have an inability to relate speed and sight distance to a suitable degree of accuracy.

Lovegrove (1978) looked at vehicles' junction approach speeds in situations for which the driver had restricted sight distance. It was concluded that the fact that many drivers were observed to exceed the calculated safe approach speed was a function of their predictions about the behaviour of other drivers. This concept appears to have much in common with the notion of schemata discussed towards the end of Chapter 1, and it is suggested that such factors be considered for the design of this study, particularly the second phase.

2.2: DRIVER BEHAVIOUR AT JUNCTIONS

2.2.1 Undesirable Driving Practices

In an attempt to provide material for driver improvement programmes, many authors have proposed that detailed descriptions of behaviour on the roads must be obtained before such suggestions are possible. Wilson (1981) argued that such descriptions of specific driving practices, particularly undesirable practices (ie. those which are more likely to result in an accident), could form the basis for effective legislation and the implementation of countermeasure strategies.

The advantage of concentrating on such undesirable practices is that this approach yields higher quality information and is more likely to provide a more accurate picture of driving behaviour than cruder measures such as traffic flow or reported accident rates. The type of undesirable driving practices suggested by Wilson include overtaking behaviours, driving at mini-roundabouts and pedestrian-vehicle incidents. A study by Clube (1979) looked at such undesirable driving practices and it was found that over 7% of vehicles observed at one mini-roundabout were involved in incidents or potentially dangerous practices. The main problem with this approach is that it offers no guidelines as to exactly what constitutes an unsafe or undesirable practice. Clube defined such a practice as one that:

"...appeared to be unusual or potentially problematical from the point of view of apparently safe driving practices." (Clube, 1979, p. 10).

Without a clearly defined structure for qualifying such practices, this approach is likely to be highly subjective. In addition, this definition does not cater for behaviours which are in contravention of the traffic laws and which do not result in an 'incident'. Although in many circumstances such behaviours can not be considered dangerous due to, for example, the absence of another vehicle, it is argued that they should be classed as undesirable because the driver is placing her/himself in a position that is more likely to result in an 'incident' than if that behaviour had not been performed. Despite this, it should be noted that, providing that a well-defined repertoire of undesirable behaviours is used, such studies of undesirable practices may be useful, particularly in 'before' and 'after' studies used to assess the adequacy of engineering modifications.

2.2.2 Identification of Hazardous Road Locations

2.2.2.1 Definition of a Hazardous Road Location

Hazardous road locations are generally confused with accident blackspots, but it has been argued that this grouping is inadequate. A 1976 report by the Organisation for Economic Co-operation and Development (OECD) differentiated between three types of high-risk hazardous locations where clusters of accidents occur: 'blackspots'; 'blacksites'; and 'black areas'. The first category was reserved for locations for which it was felt that certain aspects of the geometry of the sites, such as blind corners or junctions, were implicated in the accidents. Blacksites were defined as sections of the road network with high reported accident frequencies. Finally, the term 'black areas' was reserved for cases in which the reporting methods were not sensitive enough to identify specific locations within a wider area. However, the term 'accident blackspot' is generally used to cover all three categories.

Several methods of identifying hazardous road locations, such as use of raw accident data and multidisciplinary accident investigation teams, have previously been discussed in the opening chapter (see Sections 1.2.1 and 1.2.2 respectively). However, there are several alternative approaches, and these will now be discussed.

2.2.2.2 Accident Data and the Regression-to-the-Mean Effect

The inadequacies of using raw accident data to identify hazardous road locations have been discussed in Section 1.2.1, but there have been attempts, using more sophisticated methods of data analysis from 'before' and 'after' studies, to assess the effectiveness of remedial measures. One of the major problems with identifying such locations is known as the 'regression-to-the-mean' effect and is a consequence of the high level of variability in accident frequencies over time. The number of accidents occurring at any particular location during a specified time period is liable to change during a subsequent period of measurement. Sites are generally selected on the basis of their having accident frequencies that are above the mean for the particular population of which the chosen site is a member. For any site in this population that lies at the upper or lower end of the distribution, the future observed accident frequency is more likely to move nearer to the population mean than further away. The consequence of this is that, regardless of whether any remedial measures are made, accident rates for high-frequency locations are still more likely to fall than rise or remain the same.

Various attempts (eg. Hauer, 1980 and Abbess, Jarrett and Wright, 1981) have been made to correct the errors produced by the 'regression-to-the-mean' effect, generally relying on assumptions such as those concerning the distributions of mean accident rates between sites. A review of such methods by Wright, Abbess and Jarrett (1988) concluded that they had generally failed to account for such phenomena. In addition, they suggested that any future attempts to overcome the 'regression-to-the-mean' problem should consider factors such as: arriving at objective definitions of the population of sites studied; and sub-dividing the population of sites into categories based on physical characteristics.

Another recent attempt to assess accident blackspots (or blacksites) using modified accident data is the PAR (potential accident reduction) approach devised by McGuigan (1981) and reviewed by Maher and Mountain (1988). The PAR value calculated for a site is the difference between the observed accident frequency and the expected number of accidents for the particular type of site with a corresponding traffic flow, and this method is clearly dependent upon the accuracy of the expected accident frequency calculations. The model outlined by Maher and Mountain (op.cit.) contains three levels of information: fixed site characteristics; changeable site characteristics; and a random error component. In attempting to assess the potential for accident reduction, it is necessary to deduce the effect due to the changeable characteristics, these being obscured by the other two components. The results revealed that in most circumstances, the PAR method has no advantage over the more traditional use of annual accident totals. However, the data used to assess the model were artificially generated for the study and it is argued that PAR should be applied to some 'real' data before being condemned.

The approaches to hazardous road location identification outlined briefly in this section have looked at accidents in a more quantitative, rather than a qualitative manner, and it is argued that a deeper understanding of the types of errors made at junctions can only be derived from an analysis of specific incidents. The diagnostic technique in most common usage is the Traffic Conflicts Technique, and the main points relevant to this topic will be discussed in the next section.

2.3: TRAFFIC CONFLICTS TECHNIQUE

2.3.1 Origins and Applications of the Traffic Conflicts Technique

One of the earliest criticisms of using accident data to predict future accident rates came from McGlade and Laws (1962). Based upon the assumption that the causes of accidents and 'near' accidents are similar, these authors developed a statistical model to represent the ratio between actual, 'near' and 'far' accidents. In this context, the definition of the term 'accident' was adapted from that suggested by Suchman and Scherzer, who felt that:

"...the results of accidents could be placed on a continuum ranging from instant death to narrow escape." (Suchman and Scherzer, 1960, cited by McGlade and Laws, 1962, p. 3).

McGlade and Laws (op.cit.) altered this definition by substituting the term 'far escape' for 'narrow escape'. A 'near' accident was said to occur in situations where some form of corrective procedure, such as harsh braking, is needed by at least one driver to prevent a collision. In contrast, a 'far' accident is the result of a situation in which a driver places her/himself in a potentially dangerous position for which no emergency action is necessary, mainly due to the absence of another vehicle.

From the work of McGlade and Laws, a systematic procedure for recording conflict situations called the Traffic Conflicts Technique (TCT) was developed by the General Motors team of Perkins and Harris (1967). A traffic conflict was defined as a 'potential accident situation', was viewed as a kind of surrogate accident, and could result from two types of behaviour: evasive action taken by driver to avoid collision; and traffic violations (defined by highway laws) which do not require the presence of another vehicle.

The technique was based upon the assumption that the number of conflicts occurring at a particular site would correlate positively with the number of actual accidents at that site. In their 1968 study of driving behaviour at thirty signalised and thirty non-signalised junctions, Perkins and Harris recorded five categories of conflict:

i) left-turn (British right-turn) conflicts, where vehicle turns directly in front of another causing latter to take evasive action;

ii) weave conflicts, where vehicle changes lane into path of another, causing latter to weave or brake;

iii) cross-traffic conflict, in which vehicle crosses or turns into path of vehicle with right of way, causing latter to weave or brake;

iv) red-light violation, for which driver fails to stop at red light at junction;

v) rear-end conflict, where vehicle brakes suddenly causing following vehicle to take evasive action to avoid colliding with rear of first vehicle.

By comparing the mean number of conflicts observed per hour with the number of accidents occurring as a result of each of the five conflict classes, Perkins and Harris concluded that there was a high level of agreement between conflicts and accidents. However, their conclusions do not appear to have any statistical basis, as the Pearson's 'r' correlations performed on the data by Harris (1987) revealed that only two of the categories (iii and iv) produced 'r' values accounting for over 30% of the variance. Weave conflicts showed a modest degree of association with similar accidents (20% variance accounted for), but the remaining two categories (i and v) produced very poor correlation coefficients and make the conclusions of Perkins and Harris somewhat dubious.

Since the original model, TCT has been used extensively in various forms for three main purposes: to provide objective measures of road user behaviours in accident situations; to evaluate the effectiveness of engineering countermeasures in 'before and after' studies; and to evaluate existing situations in terms of their accident potential (Older and Shippey, 1977). However, in several cases this objectivity has been called into question as many of the studies, mainly European, have adapted the original model by including classifications of conflict severity (eg. Spicer, 1971). Authors such as Williams (1981) feel that these severity ratings introduce an unnecessary subjective component to conflict assessments, but, as Grayson and Hakkert (1987) point out, the subjective-objective debate is irrelevant providing that the conflict rating system is reliable. Some techniques that purport to be more objective have been developed, and some will be discussed briefly in Section 2.3.3.

One of the main purposes of using TCT to assess traffic situations was to provide an alternative to using accident data, and hence many studies have been carried out to uncover the relationship between conflicts and accidents. Several studies, such as that performed by Zimmerman, Zimolong and Erke (1977), have demonstrated significant correlations between accidents and conflicts and also, to a lesser degree, between conflicts and traffic volumes and between traffic volumes and accidents. Spicer (op.cit.) found a significant correlation between 'serious' conflicts and accidents when time of day and location factors were considered and concluded that there was a strong link between these serious conflicts and accidents. However, it should be noted that Spicer regarded a collision as a serious conflict and was therefore guilty of correlating two non-independent variables.

In contrast, several researchers have failed to demonstrate a significant relationship between accidents and traffic conflicts (eg. Campbell and King, 1970 and Malaterre and Muhrad, 1977) and Williams (op.cit.) feels that the problem may be due, at least in part, to inconsistencies over the definition of a 'conflict'. In an attempt to produce a standardised definition, a discussion group at the First Workshop on Traffic Conflicts in Oslo in 1977 agreed on the following definition:

"A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged." (Amundsen and Hyden, 1977).

Despite the advantages of this definition in that it allows for the possibility of a variety of procedures to be used, it also assumes that accidents are always preceded by conflicts, but, as a study by Cooper (1973) demonstrated, this may not always be the case. Cooper took a large amount of video recordings of traffic in the process of negotiating an American freeway junction and the amount of time devoted to data collection meant that a number of actual collisions were filmed. Analysis of the data revealed that many of these accidents were not preceded by the type of evasive actions suggested by TCT, and it was concluded that the events leading up to accidents may be qualitatively different from those preceding conflicts.

Grayson and Hakkert (op.cit.) feel that the disagreements brought about by these apparent contradictions are a result of Perkins and Harris defining a conflict as an event rather than a situation. They argue that it is more appropriate to view evasive action as a reaction to a conflict situation, rather than the result of that conflict situation. The definition by Amundsen and Hyden quoted previously refers to a conflict as a situation and, as Grayson and Hakkert point out, this view is becoming more widely accepted. This essentially European definition, which overcomes the problems raised by Cooper (op.cit.), has since been generally adopted by American researchers, and according to Migletz and Glauz (1984), this definition accounts for collisions for which no evasive action was taken.

2.3.2 Validity of the Traffic Conflicts Technique

Williams (1981) pointed out a fundamental flaw in the reasoning of researchers attempting to find a link between accident frequencies and traffic conflicts. It may be remembered that the main goal of TCT was to provide an alternative to accident data, known to be an unreliable measure, for evaluation of traffic situations. As Williams points out:

"It is illogical for a new research tool to be proven using data gained from the unreliable research tool it is to replace." (Williams, 1981, p. 142).

In addition to this objection, Williams pointed out that correlations between accidents and conflicts may be subject to distortion because the number of conflicts occurring at any site may display quite considerable daily variations. Indeed, a study by Hauer (1978) revealed that the conflict incidences for a single site, for which details were recorded over a three week period, showed significant daily differences. However, Harris (1987) points out that, despite this daily variability, the running mean number of conflicts remained stable from the fifth day of recording, and it may be argued that the variability problem may not particularly serious if data is collected over a longer period of time.

Attempts to use conflicts to predict future accident frequencies has been the source of another problem with much of the research in this area, mainly due to the fact that there appears to be confusion over the concept of predictive validity. Aside from the distinction between external validity (where the relationship between the phenomena being investigated and an external criteria is measured) and internal validity (in which the phenomena are assessed in terms of their relationship to the underlying theories and concepts), there is an additional distinction between two forms of external validity: concurrent and predictive.

As Grayson and Hakkert argue, many investigators have referred to their studies as 'predictive' when they are basically retrospective. Rather than actually using conflicts to predict future accident occurrence, and then assessing the accuracy of such predictions at some future point in time, these studies have compared the conflict rates to previous accident rates. The poor results should not be surprising, as Hauer and Garder (1986) have pointed out that the extent of the random variability in accident counts makes it extremely unlikely that a strong relationship would be found. Hauer and Garder suggest that it is more appropriate to think of the expected number of accidents as being given by the product of the expected number of conflicts and the conditional probability of a conflict resulting in an accident. Studies adopting this technique have shown that conflicts are at least as good as previous accident records in predicting future accidents. Referring to the progress made by Hauer and Garder, Grayson and Hakkert argue that the fundamental problem of validity within the realm of traffic conflicts research is showing signs of being resolved.

2.3.3 Alternatives Approaches to the Traffic Conflicts Technique

Several attempts have been made to produce a concept similar to the Traffic Conflicts technique without the elements of subjectivity that the standard technique, particularly the European version, demands. One such example is the 'Time-Measured-to-Collision' (TMTC) approach put forward by Hayward (1972) which assessed the level of danger inherent in a particular situation by using a measure of the amount of time remaining before two vehicles collide if their current course and speed is maintained. The theory states that as the time-measured-to-collision value decreases, the objective danger level increases and vice versa. Unfortunately, Hayward made no attempts to use the TMTC values to predict future (or even previous) accident rates and, as subsequent studies adopting this technique are quite rare, it would be unwise to draw any conclusions from it.

A criticism of the original Perkins and Harris (op.cit.) study led to the formulation of Allen, Shin and Cooper's 1978 study. They were concerned that it was misleading to record conflicts on the basis of factors such as the appearance of brake lights as there may be reasons other than perceived hazardous situations, such as a habitual precautionary braking action, that cause those factors to appear. These researchers used a variety of 'objective' measures that did not necessarily require evasive action to be taken to assess left-turn (right turn in Britain) conflicts. The most satisfactory measures in terms of their relationship to collision history, but also to other terms such as consistency and ease of measurement, were GT (gap time - the lapse between the time when one vehicle is expected to arrive at a potential point of collision if the current course was maintained and the time when encroachment by the left-turning vehicle on the through lane ended) and PET (post encroachment time - the time lapse between the end of encroachment of one vehicle on a potential collision point and the arrival of another vehicle at that point). However, despite the improved objectivity of such measures, it is argued that there must remain a certain degree of subjectivity in the selection of potential collision points. An additional problem with such techniques, particularly if they are to be used for diagnostic purposes, is that they tend to be extremely time-consuming and will not be appropriate for situations in which an 'answer' is needed quickly.

More recently, Hyden (1987) has suggested an alternative notion to that of the continuum of events, ranging from safe driving through conflicts to accident and injury, that is central to the traffic conflict concept. Hyden proposed the idea of the 'safety pyramid' (see Figure 2.1, over), which suggests that the more 'non-safe' an event is, the less frequently it will occur. This makes intuitive sense as normal driving is extremely common, whilst accidents are relatively rare events.

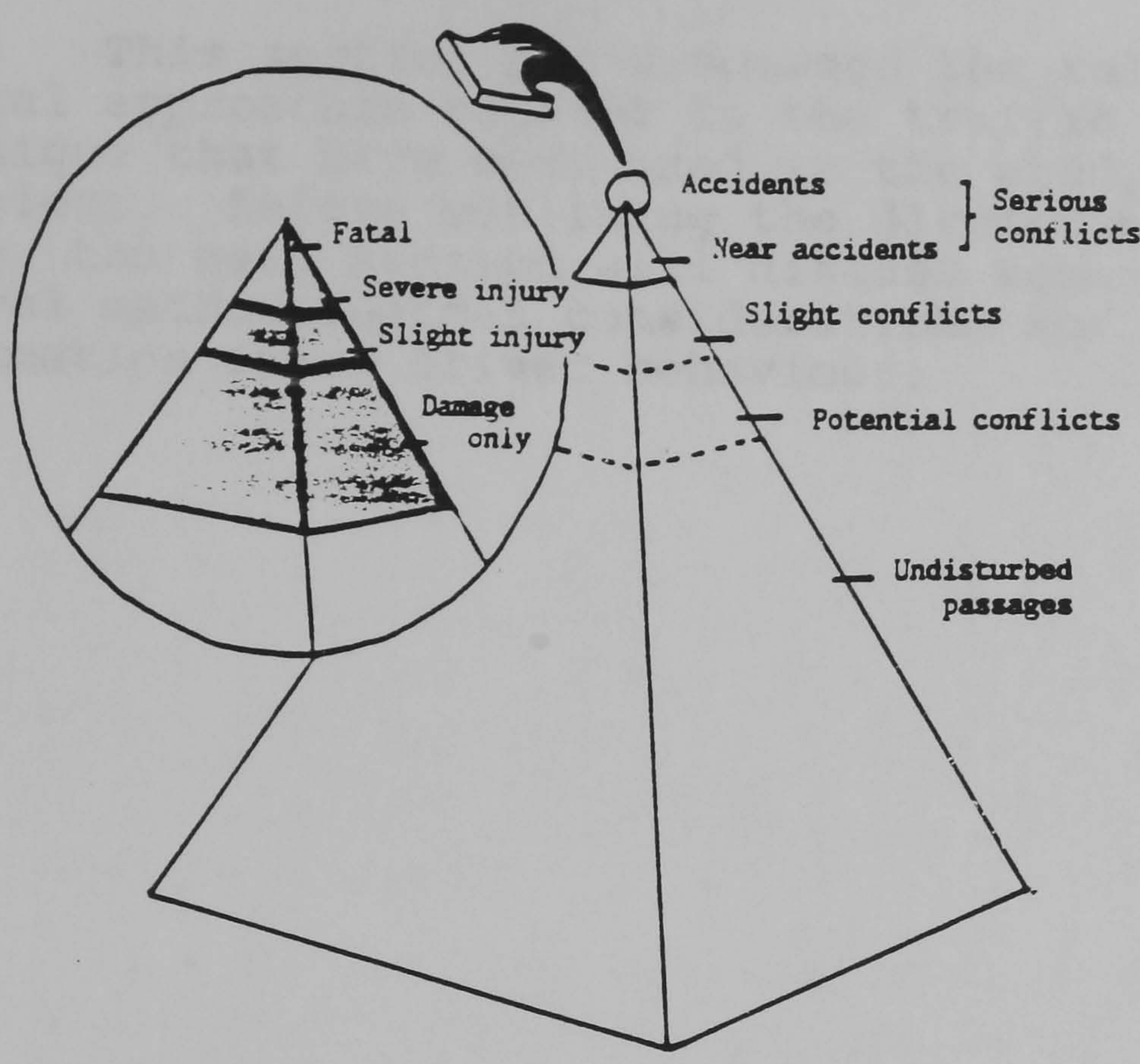

Figure 2.1 The Safety Pyramid (from Hyden, 1987)

The pyramid concept also suggests that the transitions from one event to another have conditional probabilities associated with them, and as the events become more infrequent, the accompanying probabilities are influenced by fewer external, particularly environmental, factors. For events that are very close to accidents, these probabilities rely more on human capability than environmental factors.

2.3.4 Future Applications of the Traffic Conflicts Technique

Williams (1981) feels that, whilst traffic conflicts may still be an effective method of assessing remedial measures made to accident blackspots, providing that a consistent methodology is accepted, the technique may be most effectively applied in a more diagnostic sense to reduce the number of inappropriate driving practices at site hazards. In addition, Grayson and Hakkert (1987) feel that the notion of traffic conflicts as accident surrogates is of little practical use primarily because even accurate prediction of future accident rates tells us nothing about ways in which at least some of those accidents may be prevented. These authors suggest that conflicts should be studied as critical traffic events rather than simply counted and conclude that research should focus upon the conflict as a means of studying the unsafe behaviours of road users.

This section has discussed the relative merits of several approaches related to the traffic conflicts technique that have been used in the study of driver behaviour. Before outlining the direction for this first study, the next section will discuss some of the more general methodological considerations for recording information about driver behaviour.

2.4: THEORETICAL BACKGROUND TO SELECTION OF METHODOLOGY FOR STUDY 1

2.4.1 Methods of Studying Driver Behaviour

Essentially, there are four distinct methods by which driver behaviour can be investigated: test-track studies; in-car studies; questionnaire surveys; and external observation of traffic. Test-track studies have an advantage in that the researcher is free to manipulate the driving environment to meet the specific demands of the task. However, the major problem with adopting the test-track technique is that it lacks ecological validity - in other words, the extent to which the simulation is an accurate representation of the 'real-world' driving situation is limited. There are many factors in the driving environment which have the potential to influence the behaviour of a driver, and it would be almost impossible, and certainly highly impractical, to achieve this level of accuracy.

In contrast, in-car studies have the advantage of the driver being exposed to the whole range of environmental influences, and so achieve a relatively high level of ecological validity. In addition, this is the only technique in which it is possible to study the car control movements made by drivers. The main reason why in-car studies do not achieve maximum ecological validity is that there is strong evidence to suggest that the mere presence of a researcher in the vehicle is enough to alter behaviour. Harvey, Jenkins and Sumner (1975) compared driver errors when measured by a variety of techniques and discovered that the in-car study produced a reduction in the number and severity of errors when compared with other techniques. It appears that the subjects tend to treat this kind of study as a driving test and therefore are on their 'best behaviour'. Another disadvantage is that it is considerably more difficult to record the full range of events occurring outside the vehicle, and as the current research would appear to demand a record of these external factors, the in-car technique must be rejected.

Questionnaire surveys are becoming a more widely used method for the study of driver behaviour. The main advantage of this technique is that it is able to gather levels and types of information that are not available by any other technique. This is particularly true when the researcher is investigating attitudinal or motivational factors in drivers. However, their ability to measure accurately driver behaviour is debatable. For example, Michon (1980) found a low level of correspondence between drivers' attitudes and their actual behaviours, yet the precursor to this piece of research (Bottomley, 1987) displayed a reasonably good level of agreement between observed and driver-reported occurrences of undesirable driving practices at a particular site hazard.

These shortcomings of the questionnaire technique suggest that it is not applicable to the requirements of the first study, and an alternative method must be sought. Knapper and Cropley (1980) are among the researchers who suggest using subjective measures of behaviour (such as questionnaires) with more objective measures (such as observations of behaviour) to supplement each other and form a more complete, overall impression of driver behaviour. For the purposes of the current research, it is felt that the questionnaire technique would be more effective when used to elicit information about drivers' subjective perceptions of their own driving and of the traffic system in general.

Perhaps the most obvious method of studying driver behaviour in the 'real-world' is that of direct observation. This is the technique that has the highest levels of ecological validity as the studies are carried out on public roads using subjects who are generally unaware that they are participating in the study. The amount of experimenter interference is usually negligible, and the information gathered can be assumed to be representative of the population, ie. the driving public who generally use the stretches of road in question. However, there are some disadvantages to this technique and these will be discussed briefly.

2.4.2 Potential Problems With Observation Studies

One of the major problems of this type of research technique is that of observer inference, a problem occurring in cases in which the researcher wishes to apply causality to the behaviours under investigation. The use of purely observational data means that the information being gathered is limited to the actual events that are taking place, and no inferences regarding the definitive underlying causes of those behaviours are possible. However, this may become a source of concern only in circumstances in which the classification of behaviours is quite complex and the chances of making incorrect inferences is relatively high. In ideal situations, the recording of behaviours would be totally objective. However, as Kerlinger (1973) points out, to be completely objective requires that the observer has no prior knowledge of the subject matter under investigation, and in these cases, whilst the observations may be objective, they also run the risk of being highly inadequate. It appears that the best solution is to use trained observers working with a classification system that is both as objective and as straightforward (ie. unambiguous) as possible.

Another potential problem with observing behaviour is the possibility that the behaviours under observation are affected purely as a result of being part of the observation. Kerlinger sees this as a somewhat over-emphasised problem:

"Individuals and groups seem to adapt rather quickly to an observer's presence and to act as they would usually act. This does not mean that the observer cannot have an effect. It means that if the observer takes care to be unobtrusive and not to give the people observed the feeling that judgements are being made, then the observer as an influential stimulus is mostly nullified." (Kerlinger, 1973, p. 539).

It is true that in some circumstances it may not be possible to be unobtrusive given the nature of the study and its' location, but if the observer is able to achieve a reasonable degree of aloofness, the probability of the observer having a significant influence on the outcome of the study should be minimised.

It would appear, therefore, that the most applicable technique to the current circumstances is that of direct observation. However, there are several alternative methods of direct observation, and these will be discussed in the next section.

2.4.3 Methods of Observing Driver Behaviour

Many observational studies of driver behaviour have used one or more observers positioned at relevant points at the site, each observer is generally responsible for recording a different aspect of a vehicle's passage through the site. In particular, many studies using the traffic conflicts technique (eg. Zimmerman, Zimolong & Erke, 1977 and McDowell, Wennell, Storr & Darzentas, 1983) have adopted this technique, the observers recording details of conflicts on data sheets specifically designed for the location under study. This technique is considerably more efficient in terms of the total amount of time needed to record the data, but suffers from the disadvantage of the observers having to code the incidents as they happen, with no opportunity for reflection. In addition, there can be no permanent record to allow for a reassessment of the incidents at a later stage. This ability to analyse at a later date also means that it is considerably easier to perform reliability tests on the data (see Section 3.5.1). The on-the-spot technique may be used in some circumstances, however, and Older and Shippey (1977) suggest that this technique is most useful when a rough guide to the number and location of incidents is required.

The advantages of having a permanent record of the situations to be analysed should be clear. It is not only possible for the re-assessments of incidents, but it can also allow the observer to record details of the events leading up to, and following on from, an incident. Time-lapse photography (recording approximately two frames per second) has been a well-used research tool (eg. Spicer, 1971), but it is suggested that the use of video equipment is more flexible and appropriate to the dynamic situations encountered when studying the movements of traffic.

For example, a car travelling at $12.5ms^{-1}$ (45 kmh) covers 6.25 metres in the time between two frames on a film taken by a time-lapse camera. In contrast, using the frame-by-frame advancement facility on a video recorder (the gap between two frames being 1/25th of a second), the equivalent distance covered by the same vehicle between two frames is 0.5 metres. Although it is possible to calculate a vehicle's speed using both techniques, the use of video equipment decreases the error quite considerably. In addition, video recordings are more immediately accessible, as they can be analysed as soon after the data collection as possible, whilst photographs must be developed and printed before this analysis can take place.

Malaterre and Muhlrad (1977) list three reasons why they believe that the use of on-site observers is preferable to film: high costs; difficulties in finding suitable vantage points for the cameras; difficulties in analysing the films. The first of these arguments may be true in some circumstances, but if the researcher has easy access to video equipment, the only real costs incurred are for the video tapes. The second point may also be true in some circumstances, often the presence of larger vehicles may obstruct the view, but it is surely no different for observers at the road-side. However, finding a suitable vantage point for the filming can be a major problem, and often a compromise has to be reached (this problem will be discussed in greater detail in Section 3.2). Finally, Malaterre and Muhlrad point out that analysis of video recordings calls for as much judgement on the part of the researcher as does direct observation. However, as has already been mentioned, at least the permanent record of a video allows for a re-evaluation of complex situations and therefore more reliable assessments in general can be made.

This chapter has outlined the main issues relevant to the initial phase of the research, and it has been concluded that the most appropriate technique is an observation study, using videos to record the data. The methodological considerations for the observation study have been discussed in this section, and the next section will provide a brief summary of the main points from this chapter as well as outlining the implications these have for the current study.

2.5: SUMMARY OF MAIN POINTS FROM CHAPTER 2 & CONSIDERATIONS FOR STUDY 1

The main purpose of this chapter was to outline some of the theoretical considerations for this initial study. The first section looked at some of the ways in which inappropriate driving behaviours have been studied, and discovered that the topic of undesirable driving practices leads to highly subjective analyses of behaviour but may be of use as a rough diagnostic technique. More sophisticated means of analysing accident data, particularly to overcome the regression-to-the-mean effect, were discussed but rejected due to their inability to describe, rather than simply count, accidents.

The following section investigated the main issues dealing with the traffic conflicts technique, initially proposed as an alternative to using accident data. It was noted that validity problems had been responsible for the relative failures of many previous studies, and that the theory of using TCT as an accident surrogate was fundamentally flawed. Some alternative, more 'objective', methods were discussed, but it was concluded that TCT may still be most effectively employed as a diagnostic technique to uncover unsafe driving behaviours. The next section of the chapter outlined some of the methodological considerations for the study, and it was concluded that an observation study, using video recordings to make a permanent record of the data, was the most suitable for the purposes of this part of the research.

Aside from the adoption of the observation technique, it was decided to use some form of the traffic conflicts technique in the analysis of the video recordings as it was felt that it may enable some of the factors associated with the errors made by drivers at junctions to be understood in greater detail. In addition, it was decided to record details of many other variables concerned with driving at junctions. The justifications for the use of such variables and the adoption of the methodology as a whole are detailed in the next chapter.

CHAPTER 3:

METHODOLOGY FOR STUDY 1

3.0: OVERVIEW

This chapter outlines the issues relevant to the methodology adopted in the first study, the major theoretical considerations being discussed at the end of the previous chapter. Section 3.1 deals with the method by which the sites used in Study 1 were selected. It describes the selection criteria, contact with County Councils and the assessment and final selection of the sites. In addition, the last part of this section contains a detailed qualitative analysis of the accidents that have occurred at the chosen sites over a period of three years and eight months.

The next stage of the study, outlined in Section 3.2, consisted of pilot video recordings of the selected sites so that the method which would produce the optimum amount of relevant information could be determined. The variables used in the main study had to be sufficiently detailed to provide an accurate and thorough description of the passage of each vehicle through the relevant site and Section 3.3 outlines the method by which the variables used in the observation study were derived.

The main observation study should be almost identical to the pilot study by definition. However, in addition to a description of the procedure for this main survey, Section 3.4 begins with a rationale and description of the sampling strategy employed in Study 1.

Finally, Section 3.5 deals with the analysis of the video recordings. The first part describes the use of reliability tests in the study, and this is followed by a description of the procedure utilised for the analysis of the recordings.

3.1: SELECTION OF SITES

3.1.1 Selection Criteria

The sites for the study had to comply with two basic requirements: a high accident rate and amenability to filming. As the one of the aims of the observation study is to attempt to develop a greater understanding of the factors involved with inappropriate and potentially dangerous driving practices, it was necessary to investigate sites which were likely to feature a higher number of these practices, ie. sites with relatively high accident rates. Although the previous chapter cast doubt on the relationship between accidents and conflicts, accidents are rare events and it would be necessary to record details of far more vehicles before enough accidents from which to draw reliable conclusions were recorded. Under the present circumstances, it was felt that the most appropriate alternative was to study conflicts in the diagnostic sense suggested by Grayson and Hakkert (1987).

It was decided that the definition of an accident blackspot used by many County Councils was the most appropriate to the circumstances. A site is said to be an accident blackspot if there are 4 personal injury accidents occurring in any one year or 6 such accidents in two consecutive years or 8 such accidents in 3 consecutive years. The second requirement, that the site can be easily filmed, clearly could not be implemented until a list of sites that met the first requirement had been obtained.

3.1.2 Contact with the Authorities

Two local County Councils, Bedfordshire and Buckinghamshire, were contacted and asked for their co-operation in the study (see Appendix A for a copy of the initial letter). Bedfordshire had assisted with previous research (Bottomley, 1987) and showed interest in the current project. Unfortunately, changes within the department concerned meant that they could no longer offer such assistance. However, the County Engineers Department of Buckinghamshire County Council also showed interest in the research and were able to provide a comprehensive list of sites within the county (including some details of all injury accidents at those sites between 1985 and 1987 inclusive) which met the required selection criterion.

3.1.3 Initial Video Assessments of Sites

The list provided by the council contained details of almost 100 sites, and, as it would not have been possible to record videos at all of these sites, further restrictions on the selection of sites had to be made. A number of the sites listed were stretches of road rather than junctions, and consequently these were eliminated. Secondly, those sites at which filming would obviously have been very difficult (such as motorway slip roads) were also eliminated. In addition, some sites which were situated at the far end of the county, and therefore relatively difficult to get to, were crossed off the list. This still left approximately half of the sites from the original list, and therefore it was decided to take video recordings of the ten remaining sites with the highest accident records.

The equipment used in this, and all subsequent, parts of the observation study consisted of a Panasonic WVP-A1E video camera linked to a Panasonic NV-180 portable video recorder (battery powered), mounted on a tripod for stability.

Each of the sites was filmed from all possible angles, and their suitability in terms of visibility and easy and unobtrusive placement of the equipment was assessed.

3.1.4 Selection & Description of Sites

On the basis of the information provided by these video recordings, four sites were selected for the observation study. Several of the sites that were filmed had to be rejected on the grounds that there were no suitable positions for the equipment on some or all of the approach roads. The number of sites was now reduced to six - this was thought to be too many for an in-depth study of each site, and it was decided to discard a further two.

In order that a wide range of behaviours could be recorded, it was felt that the four sites should represent a cross-section of junction types, and the final selection was made on these grounds. A brief description of each of the sites now follows, and plans of them can be found by referring to Appendix B.

Site 1: Bishopstone Cross-Roads

This is a small, rural crossroads situated just under two miles to the South-West of Aylesbury. The main road through the junction is a single-carriageway minor road running from Aylesbury to Haddenham. The side roads are slightly staggered and lead to small villages: Stone to the North-West; Bishopstone to the South-East. The roads through the junction have a weight limit, restricting the heavier goods vehicles from using the site. The junction was selected for its rural location and low traffic volume, although (for obvious reasons) there is a high correlation between these two factors.

Site 2: Roundabout at the junction of Grafton Street/Gate (V6) and Portway (H5)

This site is a large roundabout at the junction of two major roads, about half a mile to the West of Central Milton Keynes. The island at the centre of the roundabout is sunken and contains many trees and bushes. This makes it impossible for drivers to see the far side of the roundabout as they approach it. The approach roads differ in their width and number of lanes: To the North along Grafton Street (towards the suburbs of Rooksley and Bradwell Common) there are two approach lanes; to the South along Grafton Gate (towards the suburbs of Winterhill and Oldbrook) there are also two approaches; to the East, Portway leads towards the Northern edge of Central Milton Keynes and the approach has just a single, relatively wide, entrance; finally, the Western side leads to another roundabout at the junction with the A5, the approach having three lanes. The site was selected as it represents a busy suburban roundabout.

Site 3: Roundabout at the junction of Grafton Gate (V6) and Midsummer Boulevard

This roundabout is located just under half a mile due South of Site 2 along Grafton Gate, and the same distance due West of Central Milton Keynes. To the West, Midsummer Boulevard leads to the bus and railway stations, to the South to the suburbs of Winterhill and Oldbrook. In contrast to Site 2, this is a small roundabout with a low, grassy island over which it is possible for drivers to see vehicles approaching from all directions. The approaches each consist of two lanes and are all separated from the other carriageway (ie. for vehicles leaving the roundabout) by a central reservation about 32 feet wide. This site was selected to provide a contrast to Site 2, being a roundabout in a similar suburban area with a considerably lower traffic flow.

Site 4: Junction of Grafton Street (V6) with Watling Street (V4)

The final site is basically a T-junction, where Grafton Street (from Central Milton Keynes) meets the main road, Watling Street, just over one and a half miles North-West of Bletchley. As the plan in Appendix B demonstrates, things are slightly more complicated by the slip road for vehicles approaching from the North along Watling Street turning into Grafton Street, and those turning right from Grafton Street to travel North along Watling Street. All roads concerned are single-carriageway, although there is an additional filter lane in the centre of Watling Street for vehicles approaching from the South turning right into Grafton Street. The site was selected for the study as it represents a complicated T-junction with a high traffic flow, partly due to the presence of a large industrial estate about a quarter of a mile along Grafton Street.

It should be noted that, since the completion of the observation study, this site has undergone extensive alterations and is now a roundabout.

3.1.5 Accident Statistics

3.1.5.1 Background

Quite clearly, in any investigation of accident behaviour at junctions, the type and relative frequencies of those accidents should be looked into first of all. One of the primary functions of this categorisation of accidents is that it ensures that the behaviours and manoeuvres implicated in accidents at the sites are included in the classification system used in the observation study. In addition, analysis of the distribution of accidents enables a suitable sampling strategy to be adopted (see Section 3.5.1).

The initial accident data was provided by Buckinghamshire County Council and this proved useful in the initial assessment of the sites. However, this information was very basic and further details of the accidents were required.

Contact was made with Thames Valley Police (see letter in Appendix C) and both divisions involved (A-Division in Aylesbury for Site 1 and D-Division in Milton Keynes for Sites 2, 3 and 4) were keen to allow access to their accident records. All accident information in this section is based upon these records. The full details (where available) of all of these accidents are listed in Appendix D.

The period covered by the accident statistics is from January 1985 to August 1988 and this was chosen to conform to the selection criteria for the sites (see Section 3.1.1). It may be remembered that, over a period of 3 years, 8 injury accidents must be recorded at a location before it is considered an accident blackspot. At the time of contact, the council had complete records for all years up to, and including, 1987 and it was considered most relevant to look at the accidents in the three most recent years. In addition, accident records for 1988 prior to the filming of the sites (January to the end of August) were made available. It was not considered relevant to include subsequent 1988 data as the circumstances at the sites may have altered since the filming took place. This is particularly true of the drastically altered Site 4.

3.1.5.2 Severity of Accidents for all Sites

In the following section, the accidents are divided into three categories of severity in line with the police accident classification system:

Damage only - in which no personal injuries were sustained, merely damage to the vehicle(s) and/or road furniture;

Slight - in which there were slight personal injuries;

Serious - in which there were serious personal injuries.

There is an additional 'Fatal' category, but fortunately none of the accidents featured in this study produced any fatalities.

The inadequacies of using accident records to investigate driver behaviour have already been discussed in Chapter 1 (Section 1.2.1.2) and the problems are particularly relevant here. The major problem is that in some circumstances, accident records may be highly inaccurate. By definition, an accident will not be included in the police accident records unless it has been reported to them in the first place, and there will be a considerable number of accidents that go unrecorded. This must be especially true of damage-only accidents in which drivers are more able to settle the matter privately, without the threat of license endorsements or disappearing no-claims bonuses. It seems logical that the more serious the accident, the less likely it will be that drivers can avoid police (and insurance company) involvement.

In light of this, it is recommended that the damage-only figures in this section are not seen as a definitive guide to this type of accident and that they may be highly inaccurate indeed. Therefore, the accident information is presented in such a way that the data can be interpreted both with and without these figures.

Table 3.1 (over) shows the number of accidents falling into each severity category for each of the sites. The accident information was also broken down in terms of the month, day of the week, and time of day for all four sites and graphs containing this information can be found by referring to Appendix E. In addition, these accident breakdowns will be discussed briefly in the following section which looks at the accident record of each site in turn. The points raised are also relevant to the sampling strategy section in a subsequent part of this chapter (Section 3.4.1).

Table 3.1: Severity of Accidents at the 4 Sites for the Period 1985-1988 (August)

Accident Classification:

Site	Damage Only	Slight Injury	Serious Injury	Total
1	3	7	4	14
2	18	12	0	30
3	9	10	2	21
4	12	15	2	29
Total	42	44	8	94

3.1.5.3 Accident History of Site 1

In terms of severity, the most noticeable thing about accidents at the Bishopstone junction is the relatively high proportion of severe injury accidents (see Figures E.1 to E.4 in Appendix E). Additionally, there were very few damage-only accidents, and this may be a result of the problem outlined in the previous section. The fact that the site is fairly remote means that there is less chance that accidents will be witnessed or reported and the opportunity may be there for drivers to avoid contact with the authorities. This may also serve to explain why there appear to be more severe accidents than might be expected. The number of accidents producing slight injuries may be under-reported for the same reason - the incentives not to become "involved" and reach a private agreement out-weigh the desire to report the accident and the injuries produced are not sufficient to counter this. Of course, this is pure conjecture and the data may be highly representative of accidents at the site.

Figure E.2 shows the distribution of accidents over the 12 months of the year. There appears to be a noticeable cluster of accidents in late summer/autumn and, to a lesser extent, in spring. However, it is worth noting that all of the severe injury accidents occurred in the autumn months (75% of those in October). Figure E.3 shows the distribution of accidents by day of the week where twice as many injury accidents happened on a Wednesday than any other day. Finally, the most significant effect from the time-of-day graph (Figure E.4) is the number of accidents occurring between 1 and 5 o'clock in the afternoon, accounting for 9 of the 11 injury accidents. It should be remembered, however, that these figures are based upon an extremely small sample size which may not be truly representative of all accidents occurring at this junction.

Table 3.2 (below) is based upon the descriptions of the accidents contained within the police records and focuses on the different manoeuvres that resulted in each accident. In order that the damage-only accidents can be differentiated from the other categories, the data is broken down by severity ratings. The figures in brackets refer to the direction from which the vehicle at fault was travelling when the accident occurred. Question marks indicate an unknown direction.

Table 3.2: <u>Distribution of Accident Types at Site 1</u>

	Severity:			
Accident Type:	Damage Only	Slight Injury	Serious Injury	TOTAL
Vehicle pulled out of side road into path of other vehicle on main road	1 (?)	2 (SE,SE)	1 (SE)	4
Vehicle turning into side road from main road pulled into path of vehicle on main road	0	0	1 (NE)	1
Driver lost control - skidded into other vehicle	0	1 (SW)	1 (SW)	2
Driver lost control - hit road furniture	1 (NW)	0	0	1
Rear-end collision on main road	0	1 (SW)	0	1
Details not known	1 (?)	3 (?)	1 (?)	5
TOTAL	3	7	4	14

The most interesting factor emerging from these figures is that the most common type of accident, in which the vehicle pulls out of a side road into the path of a vehicle travelling on the main road, happened to vehicles entering the site from one direction (the South-East) only (with one figure missing). It could be that this is proportional to the amount of traffic entering the site from the two side roads, alternatively there may be some feature of that entrance that is not present at the North-West entrance.

3.1.5.4 Accident History of Site 2

Of the 30 accidents at this site, a high proportion (60%) were damage-only, whilst no serious injury accidents were recorded (Figure E.5 to E.8 in Appendix E). By referring to Figure E.6 in Appendix E it can be seen that the peak months were March, May and August - regardless of whether damage-only accidents are included or not. Additionally, there appear to be fewer accidents in general during the winter months than during any other season. Figure E.7 shows a trend for accidents to occur towards the beginning of the week and the weekend days are represented by one damage-only accident each. Finally, the graph showing times of day for Site 2 (Figure E.8) is very revealing in that there is a definite peak during the morning rush hours (between 7 and 10 O'clock). If damage-only accidents are also considered, there is another peak during the evening rush hours (5 to 8 o'clock). The overall suggestion from these last two graphs is that a great many accidents at this junction may involve commuters, as many occurred during the rush hours and on weekdays.

Table 3.3 (below) shows the distribution of accident types for Site 2, with the severity of those accidents and direction of approach information included as with Table 3.2.

Table 3.3: Distribution of Accident Types at Site 2

Accident Type:	Severity: Damage Only	Slight Injury	Serious Injury	TOTAL
Rear-end collision on entrance road	5 (N,?,?,?,?)	6 (S,N,N,W,N,S)	0	11
Rear-end collision on site	2 (S,N)	0	0	2
Driver lost control, skidded, hit road furniture	2 (?,?)	2 (?,W)	0	4
Driver swerved to avoid animal	1 (N)	0	0	1
Vehicle pulled out of entrance road & into path of vehicle on site	2 (?,S)	0	0	2
Collision of vehicles on site while overtaking	1 (?)	0	0	1
Vehicle cut up other while overtaking on leaving site	1 (on E exit)	0	0	1
Details not known	4	4	0	8
TOTAL	18	12	0	30

The major category of accidents at this site is the rear-end collision, responsible for 37% of all accidents. Moreover, of the twelve slight injury accidents, half of them were of this variety. All the entrance roads bar the East are represented, although the North accounts for the most. The other category that should be mentioned is the one representing drivers losing control over their vehicles and hitting some road furniture. The two accidents of this type in which slight injuries were sustained both involved motorcycles, whilst one of the two damage-only accidents involved a driver who had exceeded the alcohol limit.

3.1.5.5 Accident History of Site 3

Over half of the accidents at Site 3 occurred during 1986, the two subsequent years have yielded four accidents each. The 1987 accidents were all slight injury whilst the 1988 accidents were all damage-only (Figures E.9 to E.12 in Appendix E). Figure E.10 shows the monthly distribution of accidents and reveals a slight peak during the summer months, an effect particularly noticeable if damage-only accidents are included in the assessment. The graph of daily rates (Figure E.11) shows no clear trend although slightly greater numbers of all accident categories occurred on Mondays (Sundays being equal if damage-only accidents are eliminated). The most interesting thing about the hourly distribution of accidents (Figure E.12) is that the majority occurred during the evening period (6 o'clock to midnight) whilst no injury accidents between 9 in the morning and 4 in the afternoon were recorded.

Following the format for Sites 1 and 2, Table 3.4 (below) gives the relevant details of the alternative classifications of accidents for all categories of severity for Site 3.

Table 3.4: Distribution of Accident Types at Site 3

	Severity:			
Accident Type:	Damage Only	Slight Injury	Serious Injury	TOTAL
Vehicle pulled out of entrance road into path of vehicle on junction	1 (S)	6 (E,S,N,W,E,E)	1 (S)	8
Driver lost control - hit road furniture	3 (S,?,?)	3 (S,S,N)	0	6
Rear-end collision on entrance road	2 (S,?)	0	0	2
Details not known	3	1	1	5
TOTAL	9	10	2	21

The most represented category is that referring to drivers pulling out of the entrance road into the path of another vehicle on the site, accounting for just under 40% of all accidents. All entrance roads produced at least one such accident, and both the East and South entrances produced three. A further six accidents were a result of drivers losing control of their vehicles and hitting road furniture. Of the four such accidents for which details are known, three involved drivers approaching the site from the South.

3.1.5.6 Accident History of Site 4

Figures E.13 to E.16 in Appendix E reveal that the number of slight injury accidents at the Grafton Street/Watling Street junction has remained more or less constant over the period covered (however, it must be remembered that the 1988 records are incomplete - a third of the year's data being missing). Figure E.14, representing the monthly accident rates, shows that there is a slight winter-months peak, especially clear if damage-only accidents are included. Likewise, inclusion of these accidents also reveals a peak during the summer months of June and July. Monday is the day on which most injury accidents occurred at this site (Figure E.15). If all accidents are taken into consideration, Wednesday is the most represented day. The hourly graph (Figure E.16) shows small clusters of accidents around the morning and evening rush hours along with the lunch-time period if damage-only accidents are included.

Finally, Table 3.5 (over) shows the distribution of accident-types for Site 4, the format being identical to that used in Tables 3.2 to 3.4, with the exception of direction indicators which are rendered obsolete by the necessarily specific accident categories. The table reveals that there is one type of accident, occurring when a vehicle turns right from Watling Street (across the flow of traffic travelling along this road from North to South) into Grafton Street, that predominates. It is also worth noting that all such accidents resulted in personal injuries. The other category that is of special interest is the type of accident involving vehicles that had failed to utilise the correct procedure for turning from Grafton Street to head North along Watling Street. Once again, a high proportion (75%) of these accidents resulted in personal injuries.

Table 3.5: Distribution of Accident Types at Site 4

Accident Type:	Severity: Damage Only	Slight Injury	Serious Injury	TOTAL
Pulled out into path of other vehicle whilst turning right from main road into side road	0	5	2	7
Pulled out into path of other vehicle while turning left from side road into main road	1	0	0	1
Pulled out into path of other vehicle while turning right from side road into main road after using slip road	0	2	0	2
Pulled out into path of other vehicle while turning right from side road into main road - failing to use slip road	1	3	0	4
Rear-end collision on main road waiting to turn right into side road	0	2	0	2
Rear-end collision on side road waiting to turn left into main road	2	1	0	3
Rear-end collision on slip road waiting to turn right into main road	0	1	0	1
Details not known	8	1	0	9
TOTAL	12	15	2	29

3.1.5.7 Brief Summary of Accident Data

When the accidents described in Tables 3.2 to 3.5 are compared it can be seen that there are basically three types: The first type describes those which result from a vehicle pulling out into the path of another vehicle (or other vehicles) with right of way. This can occur when the vehicle is entering the junction or, in the cases of Sites 1 and 4, also when leaving the site. It appears that drivers are either misjudging the time taken for the other vehicle to arrive at the potential point of contact or that they fail to observe the vehicle until evasive action is no longer possible.

The second category of accident is the rear-end collision which occurred at the majority of the entrance roads at the four sites. Following distance and speed of approach are factors that may be implicated in this type of accidents. The final general accident category concerns situations in which the driver loses control of the vehicle for some reason. Certainly, a proportion of these accidents may be unavoidable (such as ones resulting from swerving to avoid an animal), and some of the others are due to impaired functioning brought about by excess consumption of alcohol by the drivers. However, some of these accidents may be due to drivers failing to drive in a manner appropriate to the prevailing circumstances, particularly in adverse weather conditions.

The information provided by this analysis of accidents at the sites will be utilised in the main observation study. However, additional details were provided by pilot video recordings and the next section discusses the method by which these pilot videos were obtained.

3.2: PILOT VIDEO RECORDINGS

3.2.1 Selection of Pilot Video Methodology

The main purpose of this part of the study was to enable the optimum positions for the video camera to be established and to produce pilot video recordings from which the variables to be used in the main study were selected. However, before these pilot videos could be taken, additional 'pre-test' recordings were taken to establish the camera positions.

The cameras had to be placed in such a way so as to ensure that as much relevant information about vehicles approaching the sites from all angles could be gained. In theory, perhaps the best strategy would have been to place the camera at a great height above the sites. However, such vantage points were not always available (at Site 1, for example) and access to the cameras to change batteries and tapes would have proved practically impossible. It was therefore felt that the camera had to be placed at ground level or at least in a raised position that was easily accessible. The main problem with adopting this approach was found to be that only a fairly limited field of vision could be obtained from any one position. In previous research (eg. Perkins & Harris, 1968), one of the answers to this problem has been to film each of the entrance roads separately, only vehicles entering by the road being filmed are focused upon in the analysis. Indeed, this method was successfully adopted in the research that served as the forerunner to the current work (Bottomley, 1987). By filming the traffic entering the site from a side road, facing the junction, it was possible to obtain details of the use of indicators and brakes from the rear ends of the vehicles in addition to environmental factors such as the presence of other vehicles on the junction.

Finding the optimum position for the camera was largely a question of trial and error. Filming a site from a distance has the advantage that a complete picture of each vehicle's approach, including close-following behaviour and deceleration rates, can be ascertained. However, this often means that very little of the activity on or near the site (such as application of brake lights) can be seen in detail. On the other hand, filming very close to a site allows this level of detail to be seen but very little of the approaches can be recorded. Additionally, this close positioning fails to include much of the activity from other parts of the site. Obviously, a compromise must be reached that includes as many of the details recorded by the closer position whilst allowing for a reasonable amount of approach road activity that would be best recorded with a camera placed at a distance.

An additional problem existed for the two roundabouts (Sites 2 and 3). Both have central reservations on all entrance roads, and recordings from cameras positioned on these were compared with recordings taken by the kerb side of the roads. Again, there were points for and against both positions. Basically, recording from the central reservation meant that the progress of the vehicle under study could be followed for the remainder of its passage through the junction. However, this meant that some information about other vehicles already on the site and approaching the entrance in question was unobtainable. The reverse problem was true when filming took place from the kerbside. Both approaches were capable of capturing potential vehicle interactions as the study vehicle entered the site, perhaps the most relevant issue here. It was finally decided that the vehicle's progress and interactions with other vehicles after it had entered the site were more important factors than more comprehensive details of other vehicles. Therefore it was decided to film these sites from positions on the central islands.

The same reasoning was then applied to the filming of the other two sites and all of the positions decided upon for the final filming were on the 'opposite' side of the road. The only exception to this was for vehicles approaching Site 4 from the South (where the vehicles turning right use a separate central lane) in which case it was found that more information about other vehicles could be obtained without losing any of the detail of the study vehicles when filming took place from the kerb side of the vehicles under study. The exact positions of the camera for each entrance road can be found by referring to the plans in Appendix B. For all locations, markers were placed on the ground at the exact position of the camera (ie. centre of the tripod) to enable precise relocation for all subsequent filming occasions.

3.2.2 Procedure for the Pilot Video Recordings

The procedure for the pilot study was virtually identical to used for the main study (described in detail in Section 3.4.2). It differed in two ways: each filming period lasted for only five minutes (a sufficient amount of data for the purposes of this section of the study); and each entrance road at each site was only filmed on one occasion - producing sixteen segments of video lasting a total of eighty minutes. The two Milton Keynes sites and the Bletchley site were all filmed on the same day, the Bishopstone site the following day (all July 1988).

3.3: SELECTION OF VARIABLES

3.3.1 Method of Variable Selection

It is argued that, for a thorough understanding of all types of behaviour at these sites, a comprehensive list of variables recording details of all stages of the approach, negotiation, and exit of vehicles at the sites must be derived. Many of the items used in the analysis of the video recordings were derived from a previous study by the author (Bottomley, 1987) observing behaviour at a small roundabout in Bedfordshire. Several problems with the methodology of this previous study used were noted and it is the aim of the current research to improve the method of assessment used in that study. The main problem with the previous study was that many of the variables used relied on very subjective categorisations. This was particularly true of the variable recording approach speed, which was coded as either 'acceptable' or 'unacceptable'. Clearly, this type of categorisation is open to a great deal of subjectivity, and attempts were made to make as many variables as objective as possible. In the case of approach speed, the time-base facility on the video camera (unavailable for the previous study) allowed for accurate speed measurements to be calculated.

In addition to using previous research to generate variables, the pilot video recordings were subjected to a qualitative analysis and items derived from these unstructured analyses incorporated into the study. The accident records described in Section 3.1.5 also contributed to the selection of variables, and one of the main criteria for an initial assessment of the thoroughness of the coding strategy was the ability to describe fully the types of behaviours that these accident records described.

The following section provides descriptions and justifications for the inclusion of all of the variables used in the observation study, along with their original source.

3.3.2 Description of Variables used in the Observation Study

3.3.2.1 Combination of Data for all Sites

It seemed logical that the same coding strategy be used to analyse all four sites so that, in addition to analyses on the sites individually, the possibility for additional analyses designed to investigate any general trends in behaviours at the four junctions existed. Indeed, it may be argued that the general characteristics of approaching the sites from most of the side roads are identical. In these cases, vehicles must 'Give Way' upon reaching the site, stopping at the line if necessary. Whether the driver decides to stop at this line or not depends, to a large extent, on the other vehicles in the vicinity. This process is identical regardless of whether the site is a T-junction, a roundabout or crossroads. The accident records suggest that, once the vehicle has successfully pulled out onto the site, the probability of being involved in an accident (as the vehicle at fault, at least) is dramatically reduced. In light of this, it was decided that the analysis would concentrate on the site approach and entrance.

However, some cases called for an alternative approach. Site 1 (Bishopstone crossroads) has two entrance roads, but some of the accidents were caused by vehicles travelling through the site along the main road, sometimes in the process of turning into one of the side roads. The same is true of vehicles travelling North along Watling Street at Site 4 with the intention of turning right into Grafton Street. Clearly, it is just as valid to study vehicles using these routes and the coding frame had to be flexible enough to accommodate them. However, the whole range of variables was not relevant to vehicles using these roads. In such cases, non-applicable values were recorded.

The progress of vehicles through a site may be split into three components: their approach; their behaviour at the 'Give Way' line (or equivalent); and their negotiation of, and exit from, the junction. In addition, there are three other general categories of variables that were used: General details of the observation period and vehicle; presence and behaviour of other road users; and traffic conflicts. These categories will now be discussed in greater detail.

3.3.2.2 General Details

Many of the variables that fall under this heading were included to enable analyses on selected portions of the data to be carried out. In addition to a case number, each vehicle was allocated a value to denote the site, time period, entrance road and lane so that any effects resulting from these factors could be studied. It is possible that some behaviours may be a function of the weather and condition of the road surface and so variables to record these factors were also included.

One of the most important general details is the type of vehicle under study and the classifications used were based upon those suggested by the Department of Transport (also used in the previous study - Bottomley, 1987). However, the DOT classifications were slightly altered in that the two-wheeled motor vehicle category was split into two sub-categories: motorcycles and mopeds. It was felt that the relevant factor contained within this variable was the handling characteristics of the vehicle and it is argued that in some circumstances the added distinction between different types of two-wheeled vehicles may be important. For example, a situation may arise in which a collision may only be avoided by rapid acceleration, something which motorcycles are more well-equipped to cope with than mopeds. It is clear that this kind of distinction is important to make - riders of mopeds may behave in an entirely different manner when riding a motorcycle.

This principle also applies to cars and consequently four categories were differentiated, based upon those used by motor manufacturers:

1) Vehicles under 4 metres in length (eg. Austin Metro);
2) Vehicles between 4 and 5 metres (eg. Ford Escort);
3) Vehicles of 5 metres and over (eg. Ford Sierra);
4) Special cars (eg. Porsche 924).

Obviously, to calculate the exact lengths of vehicles would be rather time-consuming at the time of coding the videos and not altogether accurate. A potential problem with this system is that vehicles with similar body shells may have very different performance characteristics (eg. a Triumph Dolomite 1300 and Dolomite Sprint), and such details may not always be discernible from the videos. Therefore, it should be stressed that these classifications merely served to act as general guidelines. It was intended that the basic list derived from the previous research be flexible enough to allow for additions to be made when vehicles which had not been encountered previously appeared on the videos.

The following list outlines the different categories of vehicle used in the study.

1) Car category 1 (small cars);
2) Car category 2 (medium cars);
3) Car category 3 (large cars);
4) Car category 4 (special cars);
5) Light goods vehicle (LGV);
6) Minibus;
7) Heavy goods vehicle (non-articulated);
8) Heavy goods vehicle (articulated);
9) Motorcycle;
10) Moped;
11) Bicycle;
12) Farm/Construction vehicle;
13) Car with trailer;
14) LGV with trailer/car in tow;
15) 3-wheeled car;
16) Emergency service vehicle;
17) Dustcart/Skip lorries/Cement trucks;
18) Land vehicles (Landrover etc.);
19) Taxi (Hackney carriage type);
20) Single-deck bus;
21) Coach;
22) Microvan;
23) Kit car;
24) Double-deck bus;

(cont. over)

25) Heavy goods vehicle (articulated) - Cab only;
26) Milkfloat;
27) Ice-cream van;
28) Microvan with trailer;
29) 'Pick-up'.

At this stage it was felt that relatively similar vehicle types should be coded separately, as this allowed for the possibility of re-coding at a later stage.

3.3.2.3 Approach to the Site

One of the most important aspects of a vehicle's approach to a site is the speed at which it approaches. It has already been noted that the timebase facility on the video camera used in this study allowed for accurate measurements of approach speed to be made, thereby overcoming the problem of subjectivity that was a feature of the previous study (Bottomley, 1987). However, a single measure of approach speed would clearly be insufficient as the vehicles were approaching junctions and therefore almost certainly undergoing a change in speed (ie. decelerating). By choosing five reasonably spaced reference points (in addition to the 'Give Way' line), five successive measures of speed could be calculated for all conventional approaches (ie. not slip roads) by recording the lapse between the times at which the the leading edge of the vehicle passed each two successive points. However, it should be pointed out that these speed profiles can not provide a full description of approach speeds as the measures are taken from relatively near the sites and it is possible that the most significant changes may take place in segments that are out of the range of the camera. Further details of the procedure for determination of approach speeds can be found at the beginning of the next chapter.

Another important aspect of approaching sites is the proximity of vehicles to one another. From Section 3.1.5 it was noted that many of the accidents at the four sites under study were rear-end collisions, this type of accident presumably being a function of approach speed and the gap between the two vehicles that collide. Once again the timebase facility allowed accurate measures of following time to be made, utilising one of the times used to measure speed and an additional measure which marked the time at which the rear edge of the previous vehicle passed over the same point. The difference between these two times providing a measure of the gap allowed by the driver of the vehicle under study. It should be noted that the point selected at which to measure following times was the second time recorded for the leading vehicle as the speed of that vehicle at this point could be determined and it was felt that this may become a factor in any calculations involving these variables.

It was also decided to take a measure of the equivalent gap time for the vehicle following that under study, as it may be that an intimidation effect exists. Therefore, the time at which the leading edge of the next vehicle arrived at the same marker point was noted and added to the data for the vehicle under study.

The signalling and braking activity of drivers are also factors that must be considered in a detailed study of driver behaviour at junctions. It is possible that some accidents may result from incorrect signalling behaviour and therefore the type of signalling (if any) was recorded. By analysing the signals given on the approach and on leaving the site in respect of vehicles' exit route, the presence of incorrect signalling can be detected. Additionally, the time of onset of the signal was recorded for each vehicle so that the approximate position of the vehicle at that time could be determined. The main purpose of including this variable was to ascertain whether the vehicles in question signalled before or after the 'Give Way' line.

Braking proved to be a slightly more complicated matter to record as the pilot video revealed that a high proportion of vehicles were already braking (ie. their brake lights were illuminated) when they came into view. Despite this problem, it was still considered worth recording braking activity for those vehicles who started the braking procedure after their appearance on the videos. It is argued that drivers who leave braking until they are in a position that is within range of the camera will be more likely to become involved in a conflict or an accident, and therefore their braking activity should be recorded so that their position at that time could be determined.

Finally, the presence of a queue of vehicles waiting to enter the site was recorded as this must have an influence on the approach speed and braking activity of drivers approaching the sites. This information is particularly valuable when interpreting the approach speed data, as vehicles which spent a great deal of time queuing to enter the site would confound the approach speed analyses. The actual number of vehicles in the queue was recorded at the moment when the vehicle under study arrived at the queue. In addition, the number of vehicles in the queue behind the study vehicle as it reached the 'Give Way' line was also recorded, also to investigate the possibilities of an intimidation effect. In other words, it may be that some drivers will be pressurised into taking more risks on pulling out onto the site when they have a queue of traffic behind them also waiting to enter the site.

3.3.2.4 Behaviour On Entering the Site

This section concerns details of drivers' behaviour as they reach the 'Give Way' line or, in the case of two of the approaches to Site 1 and three to Site 4, the place where vehicles wait to turn into a side road. One of the main factors is whether the vehicle actually stops at the relevant place and, if so, exactly where it stops (ie. on the line, over the line or before the line). Also of importance is the time at which the vehicle stops and a separate variable had to be created for this as the time when the vehicle reaches the line (already noted in Section 3.3.2.3) would only be equivalent to the stopping time if the vehicle pulled to a halt exactly on the line. Of course, the camera angle and the distance involved made it impossible to determine whether a vehicle stopped exactly on the line, and so only very obvious deviations from stopping on the line were recorded as such. By comparing the time at which vehicles stop at the line with those for on-site vehicles, it will be possible to determine the range of gap times that are acceptable to drivers for them to decide to pull out onto the junction.

Two other variables that are important in this respect are those measuring the time at which the vehicle pulls out onto the junction (this will be equivalent to the time at which the vehicle reaches the line for those which do not stop) and the time at which this vehicle is 'clear' of the area potentially occupied by on-site vehicles. Both of these variables serve the same function as that recording stopping time, and they will be discussed with respect to variables recording activities of on-site vehicles in the next section.

The final variable in this section is that recording the presence of another vehicle on an adjacent entrance lane at the moment of entry to the site. The reason for its' inclusion is that the presence of such a vehicle may considerably reduce the drivers' visibility (particularly relevant for those approaching in a near-side lane). The variable used was a simple dichotomous one, recording presence or absence of an adjacent vehicle upon entering the site.

3.3.2.5 Details of Other Vehicles

It may be remembered from Section 3.1.5 that, besides rear-end collisions on entrance roads, the main general category of accidents was that resulting from vehicles colliding with on-site vehicles whilst in the process of pulling out onto the junction. It is therefore argued that the activity of other, on-site, vehicles must be taken into account. Clearly, the most important aspect of an uneventful (ie. non-conflict or non-accident) pulling-out manoeuvre is the time lapse between the moment when the vehicle pulling out is clear of the area of potential collision and that when the next on-site vehicle arrives at that area. This is a similar idea to the concept of 'gap time (GT) used in the study by Allen. Shin and Cooper (1978).

For the purposes of the current research it was decided that it would be sufficient to record the on-site speed (by taking times at two locations of known separation), along with details of position on the site, signalling behaviour and destination, of the first vehicle to appear after the vehicle under study has pulled onto the junction. With this level of information, it is then possible to calculate the gap judged by the driver of the study vehicle to be acceptable to pull out onto the site.

In some circumstances, there may be a considerable time lapse before another vehicle arrives at the area immediately adjacent to the entrance road. Clearly, these vehicles are not of interest as they would not have been anywhere near the site at the moment the study vehicle pulled out and cannot have figured in the driver's decision to enter the site or not. It was decided that a cut-off point of 15 seconds (judged from the pilot recordings to be the mean time that it took for such an on-site vehicle to come into view, enter the site and pass the entrance road) would be a sufficient guide to the presence of another vehicle as the approaching driver entered the final approach road segment.

In such circumstances where an on-site vehicle does not appear for at least fifteen seconds, the same information was recorded of vehicles that were approaching or passing through the potential collision area as the study vehicle approached the site. By comparing time lapses of drivers who decided to stop at the 'Give Way' line with those who chose to drive straight through, this information may then be used to form some idea of the range of gap times that drivers will find acceptable to enter the site. Some degree of subjectivity on the part of the researcher was called for here. For each vehicle that this information was recorded, the researcher had to decide whether it would have been possible for the driver of the study vehicle to pull out onto the site into the path of the on-site vehicle if the approach speed was maintained. As it is this pulling-out behaviour that is being studied here, it is obviously of no consequence to record this information if it had not been possible for the driver of the study vehicle to pull out in front of an on-site vehicle. However, in most cases, the decision of the researcher was relatively straightforward - the delay time being obviously sufficient or insufficient for the study vehicle to pull out. In situations in which there was no on-site vehicle present, either prior to entering the site or after having passed the potential collision area, missing values were recorded for the variables concerned with other vehicles.

In order for the behaviours of drivers to be placed in context, some degree of information concerning environmental factors should be recorded. In the previously cited study (Bottomley, 1987), this was achieved by dividing the site in question (a roundabout) into six segments and, for each vehicle entering the site, recording the presence or absence of any number of vehicles in each of those segments. The information provided by this technique was not particularly useful.

In an ideal situation, it would be possible to plot the positions, relative speeds and general activity of all vehicles whose presence may have an influence on vehicles passing through the junction (at least over a such a short space of time as in this study). Quite clearly, the complexity involved in gathering and recording this amount of information is considerable, and it is argued that, for the purposes of this stage of the current research, this is not justifiable. Given that an aim of the observation study is to gain a greater understanding of the main factors leading up to accident or potential accident situations, the amount of additional effort required to obtain this level of information would not add to the end product to a sufficient extent.

It was finally decided that a compromise must be reached and a very rough guide as to the density of vehicles present on the site was chosen. This simply involved recording the number of vehicles that were in, passing through, or exiting from an area including the entrance road and the portion of the site immediately adjacent to the entrance road during the passage of the vehicle under study. Although this is a comparatively simplistic measure, it was thought to be sufficient for the purposes of this stage of the research as it allowed the factor of traffic density to be included in analyses.

3.3.2.6 Negotiation of the Site

As already noted, it was decided to concentrate on the behaviour of drivers on the approach roads and whilst entering junctions, and therefore only two bits of information on negotiation of the site were recorded: tracking and destination. The first was a dichotomous variable recording whether or not the driver selected the appropriate path given the approach lane and destination. Any deviation from the correct on-site lane was coded as an error in tracking. Finally, the exit taken by each vehicle was recorded so that this could be linked to signalling behaviour, and also served to highlight the most utilised routes through the junctions.

3.3.2.7 Traffic Conflicts Technique

Even at junctions with high accident rates, these accidents are still rare events, and clearly it would take many years of filming to obtain enough accident data from which reliable conclusions could be drawn. Therefore, an alternative method must be found. The merits and shortcomings of the Traffic Conflicts Technique have already been outlined in the second chapter (Section 2.3), and it is argued that a form of TCT is the technique most suited to investigation of the problem in a reasonable amount of time.

It is the premise of the current research that the approach suggested by Hyden (1987), which looks at the events and behaviours preceding conflicts and accidents, is applicable to developing a greater understanding of the processes involved in conflict or accident formation. Certainly, the evidence for conflicts being good predictors of accident rates is unconvincing and it has been argued that this approach is fundamentally flawed in that it can offer nothing in the way of explanations of accidents. Nevertheless, by developing a more thorough understanding of the factors implicated in accidents and conflicts, it is felt that this information can be utilised in a diagnostic sense to suggest how accident rates may be reduced.

The form of the traffic conflicts technique used in this study was based upon that utilised in the previous study (Bottomley, 1987) which has been discussed in Chapter 2. The main problem with the technique used in that study was the conceptual difficulties of Perkins and Harris' 'far accident', and it is felt that the issues implicated in that definition (eg. general traffic violations) are covered by other variables in this coding frame. However, the remainder of that conflict technique was considered to be relevant to the current research.

The method relies on the fact that there must be some observable evasive manoeuvre and the distinction is made between evasive actions that are slight and those that are severe. This is based loosely on the widely used, mainly European, conflict techniques devised by such researchers as Spicer (1971) and Hyden (1975) and, by nature, involves some degree of subjectivity. Although these studies have often been criticised for their subjectivity (eg. Williams, 1981), Grayson and Hakkert (1987) suggest that the issue of whether the conflict measures are objective or subjective is irrelevant - it is the reliability of the assessment technique that is crucial. They argue that:

"If events can be recorded in a reliable and consistent way, then it matters little how they are defined." (Grayson and Hakkert, 1987, p. 48).

The many so-called 'objective' assessment have been evaluated in the second chapter, and their suitability rejected, partly for practical reasons, as these approaches require complex analyses that are extremely time-consuming and may also contain some degree of subjectivity themselves. Tests to highlight any potential problems with reliability in this study were carried out before the analysis of the video recordings began.

The categories of conflict that were recorded were based partly upon the work of Perkins and Harris (1968) (see Section 2.2.1) and partly upon the accident types recorded at the four sites under investigation in this study (see section 3.1.5). The seven categories (not including that containing accidents for which details were not known) were as follows:

1) Left-Turn conflicts - in which the study vehicle causes evasive action to be taken by encroaching upon another vehicle's right of way when attempting to merge with the traffic flow by pulling out from a minor road into a major road. This category of conflict should not be confused with the Left-Turn conflict classification used by Perkins and Harris (1968) which translates as a Right-Turn conflict in Britain and is covered by the following category.

2) Cross-Traffic conflicts - in which the study vehicle causes evasive action to be taken by encroaching upon another vehicle's right of way when entering a minor road from a major road by crossing the opposite carriageway.

3) Rear-end conflicts - in which another vehicle takes evasive action to avoid a rear-end collision whilst on the entrance road to a junction.

4) Rear-end conflicts - in which another vehicle takes evasive action to avoid a rear-end collision whilst on the main road.

5) Overtaking conflicts - in which evasive action is taken by another vehicle as the study vehicle attempts to overtake that vehicle on the junction.

6) Cutting-up conflicts - in which another vehicle is 'cut-up' (ie. cutting across the path) by the study vehicle whilst leaving the junction.

7) Other conflict - in which the study vehicle is the 'victim' of the incident, being made to take evasive action by the action of another vehicle, a pedestrian or an animal.

In addition to the type and severity of the conflict, the types of evasive action taken were recorded, although traditionally these fall into two categories: harsh braking and swerving. When combined with other details of the approach of the vehicle, this information will provide a reasonably comprehensive guide to each conflict.

Several other details were noted for each conflict: the location of the conflict (to enable any within-site danger spots to be highlighted); the number of vehicles involved in the conflict, ie. that are seen to cause or take evasive action; and finally, the vehicle 'at fault'. This last variable may be straightforward in most cases, but for some conflicts the situation may have resulted from a number of factors and the conflict cannot be put down to the action of a single driver. It is stressed that the inclusion of this variable is merely to serve as a guide to the more obvious causers of conflicts, and for situations containing any ambiguity concerning the causal vehicle, a suitable value was recorded.

3.4: MAIN OBSERVATION STUDY

3.4.1 Sampling Strategy

In order that a representative sample of traffic passing through the junctions was obtained, the video recordings had to be taken at a variety of times throughout the day. In addition, the days on which the recordings took place had to be carefully selected as traffic flow on certain days (particularly Fridays and the weekend days) tends to be highly irregular.

Behaviours of drivers may to some extent depend on the density of traffic and it was decided that filming should take place during both peak and off-peak times. However, it was felt that it would also be useful to film during periods that were likely to maximise the number of conflicts. Obviously this could not be predicted, but it was hypothesized that the nearest estimate would be obtained from the accident records. Additionally, as the data for all four sites was to be combined, it seemed more consistent to film at the same times for all sites.

The hours between 8.00 and 9.00 am and between 5.00 and 6.00 pm tend to the main peak periods for traffic flow as these are traditionally the times during which many people are driving to and from work. As previously discussed in Section 3.1.5, the accident records of two of the sites show clear peaks at both of these times, whilst a further site shows a peak for the 8.00-9.00 period. The accident data reveals no further accident clusters (other than during the mid-evening periods during which it was found that the level of light was insufficient to film) that are common to two or more sites. It was therefore decided to adopt the same time periods as used in the previous study, the two periods already selected having also been used in that study.

There is often a smaller peak traffic flow period to be found during the lunchtime period, and so the period between 12.30 and 1.30 pm was selected on this basis. To provide a contrast to these periods, it was decided to film during two off-peak times, and the hours between 10.30 and 11.30am and 2.30 and 3.30pm were chosen.

By adopting the technique first applied by Perkins and Harris (1968), ie. that of filming and analysing each entrance road in turn, concentrating solely on vehicles entering by the entrance road under study at any one time, it was estimated from the pilot video recordings that a total sample of approximately 1000 vehicles would be obtained at all bar one site if each entrance road was filmed for ten minutes during each of the five time periods. The estimate for the other site (Site 1) was around 500, and it was decided that this would provide enough data for the purpose of the analyses whilst maintaining the consistency of technique over the four junctions. In order that the sample was made as representative as possible under the circumstances, the order in which the entrance roads were filmed was randomised. The exact order of filming at all sites can be found by referring to Appendix F.

Ideally, video recordings would have been taken of the traffic on every day of the week for a period of several weeks and a workable sample selected from this larger amount of data. Unfortunately, time constraints meant that the filming had to be completed within a relatively short space of time, preferably allocating one day to each site. Commenting upon the data reported by Hauer (1978), Harris (1987) points out that a researcher using the traffic conflicts technique should record conflicts for at least five days to allow the number of conflicts to settle to a more reliable count. However, it is argued that this is only really relevant if TCT is being used to estimate accident occurrence and the argument is not valid when the technique is being used for diagnostic purposes.

The day of the week on which the filming took place for each site was determined by the accident records. For reasons outlined earlier in this chapter, the damage-only accidents were not included in this assessment. Two of the sites (2 and 4) had injury accidents on Mondays more than any other days, a further site (3) had more on Mondays and Sundays. In this latter case, Monday was selected as the day for filming as it has already been pointed out that weekend days have a tendency to be fairly unrepresentative of the weekly traffic flow. The final site (1) had more accidents occurring on Wednesdays. The actual dates for the shooting of the videos was as follows:

Site 1 - Wednesday 17th August 1988

Site 2 - Monday 8th August 1988

Site 3 - Monday 1st August 1988

Site 4 - Monday 15th August 1988

The subjects included in the observation study were defined as those drivers whose vehicles entered one of the four junctions by the entrance road that was being filmed during each of the twenty sessions (four roads for each of five periods) for each site. Any vehicle in the process of negotiating a site when filming began was excluded from the analysis. Any vehicles which had entered the site during the ten minute period, but had not completed the negotiation of the junction when this period elapsed, were included. The filming continued until these vehicles had left the junction.

The procedure for each of the four sites was identical and is described in the next section.

3.4.2 Procedure for the Main Observation Study

Prior to the filming, it was necessary to obtain permission from the local police and the Chief Inspector of Thames Valley Police at Milton Keynes (D-Division) had no objection to the study taking place.

The equipment, including a generous supply of rechargeable batteries, was prepared prior to arriving at the site and the order of filming the entrance roads for each time period determined (using a random number generator). Upon arriving at the first entrance road, the tripod containing the video camera was placed in the correct position by the side of the road (discreet markers had been left at all the tripod positions to ensure that exactly the same location was used over the five time periods). The camera itself was exactly positioned by lining up parts of the environment with the edges in the viewfinder - sketches of the scene were made for each camera position so that exact replication could be achieved.

The recorder was left on the 'remote' setting so that the starting and stopping of the camera could be controlled from the more convenient position on the camera. Before filming commenced, it was also made sure that the timebase facility was primed so that it could be started simultaneously with the video tape.

At the appropriate time, the pause button was released and the timer started. Throughout the ten minute period, the experimenter occasionally checked the viewfinder to ensure that the area being filmed remained constant. The charge level of the battery was also monitored to make sure that the power did not run out during a filming session. At the end of the period, the pause button was pressed to halt the tape, the timer stopped and reset and the equipment transferred to the next location. Exactly five minutes after the filming of the previous entrance road had finished, the filming of the new road began, the procedure being identical. This same procedure was also carried out for all four entrance roads during all five time periods for all four sites.

3.5: ANALYSIS OF VIDEO RECORDINGS

3.5.1 Tests of Inter and Intra-Rater Reliability

One of the more pertinent issues in an observation study is that of reliability, and, if the measuring instrument (ie. the coding frame) is shown to be unreliable, little faith should be placed in the results. Kerlinger defined reliability as:

"...the relative absence of errors of measurement in a measuring instrument." (Kerlinger, 1973, p. 443).

In other words, a reliable instrument will contain little error (ie. random) variance.

One method of ensuring the reliability of the measuring instrument is to compare the observer's selection of categories for each variable on several occasions over a period of time. In addition to these tests of intra-rater reliability, it is also recommended that the observer's coding is compared with that of a second, independent observer who has also achieved a high level of intra-rater reliability. A high level of inter-rater reliability indicates that the coding frame is not specific to a single observer and can be thought of as being reliable.

For continuous data, the reliability tests are straightforward as a standard regression technique can be used. A set of variables that tend to be scored in the same fashion time after time will achieve a regression coefficient approaching 1.00 whilst those which do not show agreement will obtain scores approaching 0.00.

For categorical data, a suitable index for calculating reliability coefficients for raters observing the same set of variables was devised by Cohen (1960). Once again, perfect agreement between the raters gives a Cohen's Kappa value of 1.00, whilst a value of 0.00 indicates that the ratings are equivalent to those which one would expect if the raters were truly independent.

For the purposes of this study, it was deemed that regression/Kappa values of 0.90 or more would constitute sufficient reliability.

Tests of both inter and intra-rater reliability were carried out on the majority of the variables included in the observation study from a randomly selected sample of 24 vehicles (6 from each site) before, during and after the main analysis of the videos. The only variables which did not receive this treatment were the descriptive variables dealing with factors such as the site under study, the time period, and the approach road. Reliability tests were performed before, during and after the main analysis to ensure that an acceptable level of agreement was present at all stages of the analysis.

Most of the variables scored very highly on both intra and inter-rater reliability tests, although there were some exceptions. The only variable which had not obtained a value of 0.90 or more on the pre-analysis tests was that labelled number 36 (DENSE2), however this did achieve a level of almost 0.9 and this was considered to be sufficient given that the original criterion level was particularly high. In fact, the raters managed to obtain values over the criterion level for variable 36 in the mid and post-analysis reliability tests. The only variable for which values of 0.9 or over were not maintained in the mid and post-analysis rating sessions was number 31 (TIMEOUT). Again, the inter and intra-rater coefficients for this variable were very close to the acceptable level and this was also considered to be sufficient for the purposes of the tests. Full details of the reliability tests can be found by referring to Appendix G.

3.5.2 Procedure for the Analysis of the Video Recordings

To enable the data to be easily and accurately transferred to the computer on which the analyses were to be carried out, coding sheets were prepared (see Appendix H). The four sites were analysed individually, the separate periods for each site being analysed in the order in which they were filmed.

The analysis began by systematically following the progress of the first vehicle to enter the first site to be analysed during the first time period. For each variable in turn, a value was assigned and entered in the relevant position on the coding sheet. An editor was used to control the video cassette recorder as this allowed the observer to rewind, 'fast forward' and freeze the motion more effectively. This was particularly useful as it was impossible to assign values to all the variables in the time it took each vehicle to pass through the site. Indeed, it was usually necessary to repeatedly play the portion of the tape containing the progress of a vehicle several times before the complete set of values could be assigned. It was found that the most efficient method of analysis was to watch the entire progress of a vehicle once (without coding) to gain an overall impression of its' passage through the site. Then the tape was replayed, pausing and rewinding where necessary, and the progress of the vehicle coded.

Many of the variables required a straightforward categorisation, but those involving the use of the timebase (eg. those measuring approach speed) needed special treatment. As previously mentioned in Section 3.3.2, key landmarks (eg. white lines in the middle of the carriageway, road signs etc.) were used as the reference points for recording the time of the vehicles' appearance at that position. The most accurate way of achieving this was to draw vertical lines on the screen of the monitor in line with each of the reference points. The freeze-frame facility enabled the video to be advanced frame by frame so that the exact time at which the leading edge (or following edge in one case) of the vehicle in question corresponded with the relevant marker could be recorded. However, the time lapse between the frames was $1/25^{th}$ of a second and it was often found that the edge of a vehicle did not exactly correspond with the marker in question. In these cases the exact time was estimated by dividing the area between the previous and subsequent resting position of the vehicle into four. The segment into which the leading edge of the vehicle fell was then used to judge the appropriate compensation factor which was then added to the displayed time, the value ranging from 1 to 3 hundredths of a second. It is suggested that the estimation error in these cases is small enough to dismiss.

Full details of the process of converting these times into speeds can be found at the beginning of the results section (Chapter 4).

This method of analysis was then carried out for each vehicle entering each of the areas being filmed during each of the ten minute segments of film. The only exception to this was Site 2, the video of which was discovered to contain far more vehicles than anticipated and it was decided that a suitable sample would be achieved by analysing only half of each segment of film, the five minute portions being randomly selected.

CHAPTER 4:

RESULTS FOR STUDY 1

4.0 OVERVIEW

The previous chapter outlined the need for accurate vehicle approach speed calculations, and it was planned to use these measures of speed in several of the analyses. The first section of the results chapter (4.1) explains the method by which the five approach speeds for each vehicle were calculated. It should be noted that throughout this section, the figures for vehicles' speeds are given in miles per hour rather than the S.I. units (metres per second) as this is still the convention for Great Britain.

One of the main purposes of this study was simply to provide a description of the types of errors drivers are making at four sites representing a reasonable cross-section of junctions. Therefore, by definition, many of the statistics contained within this chapter will be of a descriptive nature, beginning with overall descriptions of the sample obtained (Section 4.2). The next section (4.3) summarises the descriptive statistics for each of the four junctions in turn. More detailed descriptions of the approach speeds, following distances, signalling behaviours, site negotiation activities, and traffic conflicts for each site are to be found in Appendix I.

Although it is not possible to make many inferences about underlying processes and motivations from the type of data derived from Study 1, it was felt that some inferential statistics could be performed, provided that the limitations of such analyses were stated. The next three sections contain details of the inferential statistics performed on the observational data, along with notes on these limitations. Analyses concentrating upon approach speeds are outlined in Section 4.4, whilst the incidence of correct indicating and site negotiating tactics are used as dependent variables in separate analyses described in Section 4.5. Finally, analyses utilising traffic conflicts as dependent variables are outlined in Section 4.6. All results are summarized in Section 4.7.

It should be noted that, for the purposes of this chapter, the variables used in this study are generally referred by their SPSS^x variable name. Therefore, a complete guide to these variable names, along with a brief definition for each, can be found in Appendix J.

The analyses described in this section were performed using SPSS^x on a VAX-11/750 VMS V4.5 computer.

4.1: METHOD OF APPROACH SPEED CALCULATION

4.1.1 Theoretical Considerations

Although it would have been possible to use the standardised score of the time taken for a vehicle to travel between two reference points as the measure of speed for the purpose of the analyses contained in subsequent sections, it was felt that absolute measures of speed would be even more useful. Each approach section of road had reference points (mainly the white lines in the middle of the road) at which the time displayed on the video could be recorded, and therefore the elapsed time between two such points could be easily calculated. A similar technique was used by Wilde, Cake and McCarthy (1976) in an observation study of driver behaviour at signalized rail crossing points.

It was found that by drawing vertical lines on the monitor screen at each of the six reference points selected (for the calculation of five approach speeds), the video could be advanced frame by frame until the leading edge of a vehicle coincided with each vertical line, the reading on the timebase being recorded on each occasion. The main problem with this approach was that the distance covered by a vehicle 'on-screen' is not the same as that covered by that vehicle in reality. An additional problem was that the vehicles very rarely travelled directly 'over' the reference points, so that the absolute distance between two such points was not equivalent to the distance actually travelled by the vehicle in the time calculated.

This problem was overcome using elementary geometric rules to infer the actual distance covered from the distance covered as it appeared on the monitor - the ratio between the actual distance travelled and the perceived distance travelled is directly proportional to the ratio between the horizontal displacement from the camera position of the reference points and the vehicle. The proof for this can be found by referring to Appendix K.

4.1.2 Procedure for Measuring Sites

This method of perceived distance calculation still necessitated the actual distance between each pair of reference points to be measured. Firstly, the reference points had to be selected. As previously noted, the most useful reference points were the white lane dividing lines present on the majority of entrance roads. These proved doubly useful in that they ensured that the various approach segment distances were roughly equivalent for each approach road and the relatively proximity to the camera position meant that they were represented with a greater degree of clarity on the monitor. This had the considerable advantage that the vertical lines drawn on the monitor screen could be placed more accurately than for more distant reference points. For a small number of points, convenient white lines were not present and alternatives had to sought, generally road sign posts or leading edges of trees.

Details of the distances of all reference points, including the relative position of the camera, were recorded using an accurate measuring wheel at each site in turn.

4.1.3 Assumptions and Approximations of Calculations

Perhaps the main assumption involved in the calculations of speed are that the vehicles in question are always travelling along a path in line with the centre of the approach lanes. This is obviously untrue for the overwhelming majority of vehicles, but it is argued that the percentage error this produces in the calculated speed is small enough to ignore. Indeed the error was calculated to be approximately 5% (see Appendix K). In addition, it may be assumed that the degree of over-estimation in speeds will be equal to, and therefore compensated by, the degree of under-estimation when the whole sample is taken into consideration. For vehicles which strayed from the centre of the approach lane by such a degree that they straddled the white lines in the centre of the road, speed calculations based upon entirely different sets of measurements were made.

4.2: GENERAL DESCRIPTIVE STATISTICS

4.2.1 Number of Vehicles Studied at Each Site for Each Time Period

Details of a total of 3654 vehicles were coded from the video recordings. Table 4.1 (below) shows the total number of vehicles observed at each site in each of the five time periods. The figures in brackets represent the column percentages, ie. the proportion of the total number of vehicles observed at each site that were present in each time period.

Table 4.1: Number of Vehicles per Site per Time Period

Time Period	Site 1	Site 2	Site 3	Site 4	TOTAL
8.00-9.00	102 (26.3)	355 (29.2)	278 (23.6)	195 (22.3)	930 (25.5)
10.30-11.30	51 (13.1)	162 (13.3)	188 (16.0)	130 (14.9)	531 (14.5)
12.30-13.30	67 (17.3)	263 (21.7)	210 (17.8)	154 (17.6)	694 (19.0)
14.30-15.30	67 (17.3)	146 (12.0)	219 (18.6)	141 (16.1)	573 (15.7)
17.00-18.00	101 (26.0)	288 (23.7)	283 (24.0)	254 (29.1)	926 (25.3)
TOTAL	388 (10.6)	1214 (33.2)	1178 (32.2)	874 (23.9)	3654 (100.0)

It should be noted that the sample from Site 2 was taken from only half of the entire video footage taken. During the course of the analysis it transpired that the total number of vehicles present on the video was far more than was necessary for the purposes of the this study, and it was decided to merely use the first five minutes of each ten minute segment.

The table above shows the expected morning and evening peaks, with a very slight peak occurring around lunchtime. However, close analysis of the table reveals that this is not true for all sites. In particular, many more vehicles went through Site 4 during the evening rush-hour than during the morning rush-hour. The lunchtime semi-peak was absent at Sites 1 and 3, although the same number of vehicles during the lunchtime and afternoon periods were recorded at the former site. Site 2 displayed the most noticeable lunchtime peak, the figure approaching that of the evening rush-hour.

4.2.2 Proportion of Vehicle Types at Each Site

Table 4.2 (below) shows the distribution of vehicle types recorded at each of the junctions after the categories had been re-coded into 9 more widely defined vehicle types. The distribution of the original vehicle classifications can be found in Appendix L. The vehicles were re-coded in this manner partly for ease of presentation at this stage, but also for further analyses when small sample sizes for many vehicle categories meant that this re-coding was necessary. The categories were chosen for logical reasons, and were based upon those used in the author's previous study (Bottomley, 1987). The figures in brackets are the column percentages revealing the proportion of each vehicle class recorded at each site.

Table 4.2: Distribution of Re-coded Vehicle Categories for Each Site

Vehicle Type:	Site 1	Site 2	Site 3	Site 4	TOTAL
Car	331 (85.3)	1063 (87.6)	923 (78.4)	703 (80.4)	3020 (82.6)
Motorcycle	1 (0.3)	12 (1.0)	5 (0.4)	10 (1.1)	28 (0.8)
Moped	3 (0.8)	3 (0.2)	5 (0.4)	4 (0.5)	15 (0.4)
Bicycle	5 (1.3)	0 (0)	6 (0.5)	3 (0.3)	14 (0.4)
Light Goods etc.	41 (10.6)	60 (4.9)	76 (6.5)	95 (10.9)	272 (7.4)
Heavy Goods etc.	4 (1.0)	39 (3.2)	32 (2.7)	52 (5.9)	127 (3.5)
Bus/Coach	1 (0.3)	26 (2.1)	120 (10.2)	5 (5.7)	152 (4.2)
Slow moving vehicle	1 (0.3)	11 (0.9)	11 (0.9)	2 (0.2)	25 (0.7)
Emergency Service	1 (0.3)	0 (0)	0 (0)	0 (0)	1 (0.0)
TOTAL	388	1214	1178	874	3654

Table 4.2 reveals that the overwhelming majority of vehicles were cars, with light goods vehicles (the second most common category) having over 11 times fewer examples. One of the most striking features from this table is the high number of buses recorded at Site 3 and this probably also explains why slightly fewer cars were at this site during the time period covered. It is worth noting that the two roundabouts (Sites 2 and 3) had proportionally fewer light goods vehicles than the other sites.

4.2.3 Traffic Conflicts

4.2.3.1 Severity of Conflicts at Each Site

It may be remembered that the traffic conflicts technique was used as a rough guide to the errors that drivers made at the junctions studied. A distinction was made between slight and severe conflicts, and Table 4.3 (below) shows the number of both types of conflict that were observed at each junction, including the number of successful (ie. non-conflict-producing) passages at those sites.

Table 4.3: Severity of Traffic Conflicts Observed at Each Site

	Site				
Conflicts	1	2	3	4	TOTAL
None	367 (94.6)	1115 (92.4)	1090 (92.5)	821 (93.9)	3393 (93.0)
Slight	21 (5.4)	88 (7.3)	84 (7.1)	50 (5.7)	243 (6.7)
Severe	0 (0.0)	4 (0.3)	4 (0.3)	3 (0.3)	11 (0.3)
TOTAL	388	1207	1178	874	3647
% Vehicles Involved in Conflicts	5.4	7.6	7.5	6.1	7.0

In total there were 254 conflicts: 243 slight and 11 severe conflicts. This means that 7% of vehicles passing through these junctions were involved in some form of traffic conflict, corresponding with Clube's (1979) finding. It should be noted that 7 missing values were recorded at Site 2 because vision was obscured to such an extent for these vehicles that it was not possible to determine whether that vehicle had been involved in any type of conflict. Site 1 had proportionally fewer conflicts than the other sites, and produced no severe conflicts at all. It is interesting to note that the roundabouts had proportionally more conflicts than the other two junction, but it should be added that the differences are small.

4.2.3.2 Number of Conflict Types at Each Site

It may be remembered from Section 3.3.2.7 that, based upon the accident records of the sites and the work of Perkins and Harris (1968), the conflicts were sub-divided into seven categories. Table 4.4 (below) details the quantity of each type of accident that was observed at each junction. It should be noted that the absence of categories 5 and 6 indicates that no such conflicts were observed at any of the sites. In addition, a slash indicates a conflict type that was not possible at a particular site, given the nature of that junction. The figures in brackets refer to the percentage of conflicts falling into each category for each site. Full details of these conflicts, including information concerning approach lanes, can be found for each junction in Tables I.5, I.11, I.16 and I.21 in Appendix I.

Table 4.4: **Conflict Types Observed at Each Site**

Conflict Type	Site 1	Site 2	Site 3	Site 4	TOTAL
1 - Left-turn	9 (42.9)	63 (68.5)	75 (85.2)	23 (43.4)	170 (66.9)
2 - Cross-Traffic	3 (14.3)	/ (-)	/ (-)	11 (20.8)	14 (5.5)
3 - Rear-end, junction entrance	3 (14.3)	26 (28.3)	10 (11.4)	17 (32.1)	56 (22.0)
4 - Rear-end, main road	6 (28.6)	2 (2.2)	2 (2.3)	2 (3.8)	12 (4.7)
7 - Other vehicle responsible	0 (0)	1 (1.1)	1 (1.1)	0 (0)	2 (0.8)
TOTAL	21	92	88	53	254

Table 4.4 reveals that by far the most common type of conflict is the left-turn conflict, accounting for over two-thirds of all conflicts. Cross-traffic conflicts were able to account for just over 5% of all conflicts, but it should be noted that, due to its' nature, this form of conflict was not possible at the two roundabouts. The nearest possible equivalent was Category 6 (cutting-up when leaving the site) but none of these conflicts were recorded. The rear-end shunt-type conflict accounted for a further quarter of all conflicts, with the majority (56 out of 68 - 82.3%) occurring in queues at the entrances to junctions. The only other type of conflict recorded was that in which the study vehicle took evasive action to avoid colliding with another vehicle. Only two of these conflicts were noted, one at each of the two roundabouts, and resulted from another vehicle pulling out of the subsequent entrance road to that used by the study vehicle straight into the latter's path.

4.2.3.3 Vehicle Types Involved in Conflicts

It may be that certain vehicle types are over-represented in the conflict-involved vehicles group, and it is clear that any such effects should be investigated. As only fourteen conflicts of the cross-traffic variety were recorded, it was felt that for the purposes of this, and some subsequent, sections, they could be combined with the left-turn conflict category as both can be thought of as involving similar judgements to be made about on-site traffic. This leaves three categories of conflict as follows:

1) Left-turn type conflicts, regardless of the specific manoeuvre;

2) Rear-end-shunt-type conflict, regardless of the location;

3) Other, in which the conflict was caused by a vehicle other than the study vehicle and which cannot be classed in either of the two previous categories.

Table 4.5 (over) shows the frequency with which each vehicle type was involved in each of the three classes of conflict. The figures in brackets give the row percentages. It should be noted that the data for all sites was combined for the purposes of this analysis.

Tables M.1 to M.4 in Appendix M show the full distribution of vehicle classes involved in conflicts for each entrance road at each junction. Perhaps the most significant factor revealed by these tables is the very high proportion of motorcycles involved in conflicts, all of them of the Class 1 (left-turn) variety. Also of note is the relatively high proportion of heavy goods vehicles in the same conflict category. The other main type of traffic conflict, rear-end conflicts, almost exclusively involved cars as the study vehicle, light goods vehicles being the only other vehicle type involved in more than one such incident.

Table 4.5: **Vehicle Types Involved in Conflicts**

Vehicle Type	Conflict-Type None	1	2	3	TOTAL
Car	2800 (92.9)	150 (5.0)	61 (2.0)	2 (0.1)	3013
Motorcycle	25 (89.3)	3 (10.7)	0 (0.0)	0 (0.0)	28
Moped	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	15
Bicycle	14 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	14
Light Goods etc.	252 (92.6)	15 (5.5)	5 (1.8)	0 (0.0)	272
Heavy Goods etc.	118 (92.9)	8 (6.3)	1 (0.8)	0 (0.0)	127
Bus/Coach	143 (94.1)	8 (5.3)	1 (0.7)	0 (0.0)	152
Slow moving vehicle	25 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	25
Emergency Service	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1
TOTAL	3393 (93.0)	184 (5.0)	68 (1.9)	2 (0.1)	3647

4.2.3.4 Other Vehicles Involved in Conflicts

In addition to looking at the types of study vehicles (ie. those vehicles about which full details were recorded) involved in conflicts, it was also considered relevant to look at the types of vehicles those study vehicles 'conflicted' with. Table 4.6 (over) shows the distribution of these other vehicles for all three classifications of conflicts. Once again, the data for all sites is presented in a combined format. The figures in brackets refer to the proportion of vehicles involved in each type of conflict in isolation. Three extra categories had to be created for this table, two for cases in which two other vehicles (of different types) were involved. The third category is reserved for cases in which there did not appear to be any other vehicle involved, and the study vehicle took evasive action for no apparent reason. It should be noted that, for logical reasons, this type of conflict was only possible under Class 1 of conflict, and even then, reservations about whether this type of incident falls within the realm of the definition of a traffic conflict should be held.

Tables M.5 to M.8 in Appendix M show the full distribution of other vehicles involved in conflicts for each entrance road at each site.

Table 4.6: **Other Vehicles Involved in Conflicts**

Vehicle Type	Conflict Type 1	2	3	TOTAL
Car	138 (75.0)	57 (83.8)	1 (50.0)	196 (77.2)
Motorcycle	0 (0.0)	0 (0.0)	1 (50.0)	1 (0.4)
Moped	2 (1.1)	0 (0.0)	0 (0.0)	2 (0.8)
Bicycle	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.4)
Light Goods etc.	12 (6.5)	6 (8.8)	0 (0.0)	18 (7.1)
Heavy Goods etc.	9 (4.9)	2 (2.9)	0 (0.0)	11 (4.3)
Bus/Coach	12 (6.5)	2 (2.9)	0 (0.0)	14 (5.5)
Slow moving vehicle	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.4)
Emergency Service	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Car & HGV	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.4)
Car & Bicycle	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.4)
No other vehicle	8 (4.3)	0 (0.0)	0 (0.0)	8 (3.1)
TOTAL	184	68	2	254

The main finding from this table is that the majority of other vehicles involved in conflicts were cars. Additionally, a larger proportion of cars than might be expected were involved in the second class of conflict. However, the most interesting feature of this analysis is the combinations of vehicles involved in conflicts. Table M.9 in Appendix M shows these combinations with the data for the four sites being differentiated. The main points from this table include the fact that 66% of all conflict interactions were car-car. However, it should be noted that Site 3 produced two combinations that were more prevalent than might be expected: car-bus and car-light goods vehicle, the former combination occurring more frequently than the latter.

4.2.4 Other General Details

Several additional general descriptive details will be outlined briefly in this section. Table 4.7 (below) shows the mean approach speeds for all vehicle types recorded at all four junctions. The mean approach speeds recorded in each of the five approach road segments (see Section 3.3.2.3) is shown for all junctions with the data for all entrance roads for any one site being combined in this table. Appendix N contains the complete details for each site individually. It should be remembered that SPEED1 denotes the approach speed of the vehicle at the furthest point from the junction entrance, SPEED5 the speed in the final section of approach.

Table 4.7: Mean Approach Speeds for the Four Sites

	Site: 1	2	3	4	Mean
SPEED1	28.10 (10.90) (385)	29.33 (9.72) (1195)	31.65 (11.48) (1171)	22.10 (12.80) (855)	28.24 (11.48) (3606)
SPEED2	31.75 (13.63) (385)	27.17 (8.75) (1196)	28.05 (10.04) (1175)	17.55 (6.68) (759)	25.89 (11.08) (3515)
SPEED3	33.22 (15.55) (358)	25.10 (7.63) (1191)	24.22 (8.58) (1174)	15.59 (7.75) (646)	23.83 (10.85) (3369)
SPEED4	33.62 (14.86) (330)	22.55 (8.06) (1192)	21.65 (10.69) (1174)	13.37 (6.75) (442)	22.08 (11.65) (3138)
SPEED5	32.50 (21.10) (329)	18.83 (16.65) (1179)	17.77 (12.67) (1172)	9.87 (4.69) (340)	18.90 (16.86) (3020)

It may be remembered from Chapter 2 (Section 2.1.1) that close-following was highlighted as one of the major potential problems whilst approaching junctions and therefore the following table (4.8, below) also contains the mean following time for vehicles at each junction. From field studies, Rockwell (1972) found that drivers had a mean following time of between three and four seconds. However, a study by Colbourn, Brown and Copeman (1978) found that drivers tended to aim to maintain a following time of around two seconds. Therefore, the table over shows the percentage of following times under three seconds and under two seconds. This table also presents information concerning the incidence of correct site tracking and signalling at each site.

Table 4.8: Mean Following Time, Percentage of Following Times Below 3 and 2 Seconds Percentage of Correct Signalling and Site Tracking for Each Site

	Site: 1	2	3	4	Mean
Following Time (secs)	27.38 (40.87) (363)	8.79 (13.46) (1158)	17.73 (29.87) (1135)	13.61 (31.51) (833)	14.78 (28.14) (3489)
% Following Times Under 3 Seconds	31.7 (363)	37.5 (1158)	25.6 (1135)	40.5 (833)	33.7 (3489)
% Following Times Under 2 Seconds	23.1 (363)	24.7 (1158)	14.9 (1135)	23.6 (833)	21.1 (3489)
% Correct Signalling	82.0 (388)	38.3 (201)	86.7 (1178)	70.7 (867)	77.0 (2634)
% Correct Tracking	94.3 (388)	94.9 (1204)	78.2 (1174)	97.9 (874)	90.2 (3640)

The information contained in the preceding two tables will not be discussed here as each issue is outlined in greater detail for each site in turn in the next section.

4.2.5 Summary of Section 4.2

The distribution of the number of vehicles studied for all sites per time period was as expected, with peaks during the morning and evening sessions and a smaller peak at mid-day. However, there were slight site-specific variations from this pattern. The vast majority (over 80%) of vehicles were cars, which were re-coded into one category. Overall, 7% of vehicles were involved in traffic conflicts, the two roundabouts having a slightly higher vehicle-to-conflict ratio than the other two sites. The conflicts were divided into two main categories, the most commonly observed type being the left-turn conflict. Motorcycles were found to be the most over-represented vehicle class in this form of conflict. The second category of conflict was the rear-end type, which mainly featured cars as the study vehicle. Overall, about two-thirds of the conflicts were car-car interactions although many more car-bus and car-LGV interactions than expected were recorded at Site 3.

4.3: SITE-SPECIFIC DESCRIPTIVE DETAILS

4.3.0 Overview

The following sections provide brief summaries of the main descriptive statistics for each of the four junctions. In addition to more basic information, such as details of the number of vehicles using each entrance road during each time period, some information about the approaches and junction negotiation tactics of drivers were recorded. Finally, the number of traffic conflicts recorded at each site are noted. A more comprehensive guide to these descriptive statistics can be found by referring to Appendix I.

4.3.1 Summary of Descriptive Details for Site 1

The two main road junction 'entrances' proved to be the most-used by far, accounting for 75% of all vehicles. Approach speeds for vehicles entering via the minor roads showed the expected decline as the site neared, and almost a third of following times for all entrances were under three seconds and just under a quarter were less than two seconds. 65% of drivers making left turns, particularly when turning from a minor to the major road, used the correct direction indication and 10% of vehicles travelling across the site from one minor road to the other were seen to negotiate the junction correctly. In addition, drivers turning right from a major to minor road were often poor junction negotiators. The left-turn conflicts were predominant among vehicles turning from a minor into the main road whilst the majority of the rear-end conflicts involved vehicles travelling from the South intending to turn right.

4.3.2 Summary of Descriptive Details for Site 2

The three-lane West entrance was by far the most commonly used at this junction, particularly during the morning peak period. Vehicles were recorded as approaching the site more quickly in outside lanes than inside lanes at all entrances with multiple lanes. Due to obscured vision, only the correct use of signals given by drivers turning left could be recorded. The success rate for this was found to be very low with only 38% of drivers giving left signals when taking the first exit, and around 70% of drivers using the East and South approaches gave an inappropriate, or no, signal. In contrast, site negotiation for left-turning drivers was excellent with over 98% of drivers performing this manoeuvre correctly. Over two-thirds of conflicts were of the left-turn type of which 38% involved study vehicles approaching from the West. This entrance also accounted for the highest proportion of rear-end conflicts.

4.3.3 Summary of Descriptive Details for Site 3

Almost 75% of all vehicles were observed to approach this junction from the North and South entrances, with the former more popular during the morning peak period, the latter during the evening peak. As with Site 2, approach speeds were noticeably greater in outside lanes, although the highest speeds tended to be adopted by drivers which did not strictly adhere to an entrance lane. The North and South entrances also produced proportionally more vehicles following the preceding vehicle with a gap of less than three seconds. Most of the drivers travelling straight across the site or turning right gave correct indications, but only 72% of drivers turning left could achieve this. However, left turns were generally well executed, with about 97% of these manoeuvres performed correctly. The relatively high proportion of straight-lining at this junction reduced the overall tracking success rate to 78%. The majority of conflicts (85%) were of the left-turn variety, and the West entrance produced the greatest vehicle-conflict ratio with 1 in 13 vehicles approaching from this direction being involved in some form of near-miss. However, the rear-end conflicts were most prevalent at the North and South entrances.

4.3.4 Summary of Descriptive Details for Site 4

The two routes taking vehicles from South to East and from East to South accounted for 88% of all vehicles for which details were recorded at this junction, the latter route particularly during the evening peak period. Only 51% of drivers turning left gave the correct signal, although in contrast over 95% of drivers using the South to East route gave the appropriate right-hand signal. The vast majority of drivers (98%) were observed to negotiate the junction correctly, this being particularly true of drivers taking right turns. Two-thirds of conflicts were of the left-turn type, East to South travelling vehicles accounting for more of these conflicts than those taking other routes. The drivers involved in most rear-end type conflicts were those turning right into the East road having travelled from the South.

4.4: INFERENTIAL STATISTICS - APPROACH SPEEDS

4.4.0 Overview

Prior to discussing the inferential techniques in this section, it should be pointed out that the tests were performed with some reservations in mind. The problems of combining data from different sites should be fairly obvious, but it is argued that the tests which concentrated on one specific site should also be treated with the same degree of caution. One of the issues that emerged from the descriptive statistics in the previous sections was that each entrance lane at each entrance road at each junction revealed different problems and different patterns of driver behaviour. It is felt that combining data in the method described will only serve to obscure any such effects and a complete analysis of the data should treat each of the entrances as, effectively, a separate junction. However, it is argued that the combination of data in the way described in this section is justified in that it may reveal possible effects that may warrant further investigation. Additionally, some of the tests described (eg. the discriminant function analyses with Class 2 traffic conflicts as the predicted variable) would not stand up to individual lane (or even site) analyses due to the small sample sizes involved in some sub-groups (eg. poor junction negotiators).

4.4.1 Analyses of Variance Comparing Approach Speeds of Different Vehicle Classes

One of the most useful set of variables in the observation study for use in inferential analyses are those relating to approach speeds. It was hypothesized that approach speeds may vary between different vehicle types and it was felt that an analysis that looked for such differences would be able to offer potentially useful information for further analyses and the questionnaire.

As this data is of a continuous nature, it would be possible to perform a series of T-tests on pairs of vehicle types. However, this would involve making 36 such comparisons between the 9 vehicle classes for each speed. If an alpha level (the probability of making a Type I error, ie. when the null hypothesis is falsely rejected) of 0.05 is adopted, the probability of making at least one Type I error becomes 0.842 (84.2%) for each speed measure in turn (see Chapter 8 of Hays, 1988). Clearly, this is inadequate and an alternative must be sought. The usual way method of performing the equivalent of these multiple T-tests without the reservations is by utilising a one-way analysis of variance (ANOVA) model in which the distributions of cases on a dependent variable (in this case, speed measures) are compared between differing levels on an independent variable (vehicle type).

Firstly, the data for all four sites were combined for a single analysis. However, this procedure may obscure any effects that are unique to a particular site, and so separate analyses were also carried out for each site independently. These separate analyses were restricted to the first and last measures of approach speed taken as it was felt that these were the most important of the speed variables. It should be noted that only those vehicles which did not have to queue to enter a site were included because it was felt that the behaviour of vehicles in the extremely slow-moving queues would distort the picture obtained, and it is argued that it is the behaviour of vehicles with a more or less uninterrupted passage through the sites that is important at this stage. Also excluded were the vehicles travelling through Site 1 which therefore were not in the process of entering a junction. Several of the vehicle categories at some junctions contained too few cases to be included in the analysis and were therefore removed.

Table 4.9 (below and over) shows the summary statistics for the analyses performed, including the F-ratios, degrees of freedom, and significance of each solution. In addition, values of omega-squared, the strength of association between the variables, are included for each solution. The null hypothesis is the same for each test: that there are no differences between the approach speeds adopted by drivers of different vehicle types on the approach to the junction. In order to determine which vehicle classes were significantly different from which others, Newman-Keuls paired comparisons between means were performed for the statistically significant ANOVA tests. Appendix N contains the means and standard deviations of the approach speeds for all analyses in this section, along with the complete ANOVA summary tables and details of the post-hoc analyses.

Table 4.9: **Analysis of Variance Summary Statistics for Comparisons Between Approach Speeds of Different Vehicle Classes**

	Degrees of Freedom	F-Ratio	Significance	Estimated Omega Squared
SPEED1 - All Sites	7,70	2.43	0.028	0.114
SPEED1 - Site 1	1,82	2.18	0.143	0.014
SPEED1 - Site 2	5,55	3.86	0.005	0.190
SPEED1 - Site 3	4,40	0.36	0.835	0.000
SPEED1 - Site 4	2,132	0.13	0.875	0.000
SPEED2 - All Sites	7,60	2.83	0.013	0.159

(cont. over)

Table 4.9: Analysis of Variance Summary Statistics for Comparisons Between Approach Speeds of Different Vehicle Classes (cont.)

	Degrees of Freedom	F-Ratio	Significance	Estimated Omega Squared
SPEED3 - All Sites	7,85	2.51	0.022	0.102
SPEED4 - All Sites	7,63	3.44	0.004	0.194
SPEED5 - All Sites	7,68	2.46	0.026	0.118
SPEED5 - Site 1	1,64	0.12	0.732	0.000
SPEED5 - Site 2	5,43	2.13	0.080	0.103
SPEED5 - Site 3	4,44	2.78	0.038	0.127
SPEED5 - Site 4	2,42	0.24	0.791	0.000

The table shown above reveals that the analyses containing data from all four sites had F-ratios that were significant at the 5% level, and in these cases the alternative hypothesis, that the speeds in each of the approach sectors are significantly different for the eight vehicle classes, must be accepted. However, it is argued that a more useful statistic is the one which indicates the proportion of the variance of the dependent variable (ie. speed) accounted for by the different treatments (ie. vehicle types). The values of omega squared obtained for the tests using combined data are relatively high, ranging from 10.2% (SPEED3) to 19.4% (SPEED4) variance accounted for.

However, when the tests were performed on data from individual sites, the results were less impressive. Only one of the site-specific analyses for SPEED1 produced an F-ratio significant at the 5% level (at Site 2), and the accompanying values of omega squared were equally disappointing with only the Site 2 analysis producing a noteworthy value. The analyses for SPEED5 were similar to those for SPEED1, with only one (Site 3) producing an F-ratio that achieved significance at the 5% level, although the Site 2 analysis produced an F-ratio with a significance level of 8%. The Site 2 and Site 3 tests also produced omega squared values greater than 0.1 (ie. more than 10% variance accounted for), displaying a modest level of predictive association.

The Newman-Keuls post-hoc comparisons that were carried out on the statistically significant ANOVAs revealed little of interest, the only vehicle-type that was found to have significantly different approach speeds from other classes was the bicycle.

Analysis of the mean approach speeds for vehicles not faced with a queue on the approach reveals that, although the figures for most vehicle classes at each entrance to each site show the expected gradual reduction, some irregular patterns are apparent. One of the most obvious differences concerns the final mean approach speeds (ie. in Sector 5) of motorcycles and mopeds. For all sites, the mean speeds of both these classes of vehicles showed an increase during this final section, this effect being particularly evident at Sites 2 and 3. In other words, the mean speeds of these types of vehicles show a tendency for them to accelerate onto the junction in question.

The other noticeable factor about these figures once again concerns the speed in the final approach sector, SPEED5. In the cases of most vehicle classes at most sites, the variability of approach speeds was far greater in this sector than in any of the four previous sectors. However, Site 4 was exceptional in this respect, with only two vehicle classes, mopeds and bicycles, conforming to this apparent trend. The speeds of the remaining classes generally showed more variation in the first, rather than the final, approach sector.

4.4.2 Multiple Regressions With Speed Measures as Dependent Variables

Having established that there are few substantial differences in the approach speeds of various vehicle types, it was decided to investigate which, if any, factors influenced these approach speeds and the extent of any such influence. Multiple regression analysis is a technique which allows the researcher to study the relationship between a number of predictor (or independent) variables and a single predicted (dependent) variable. It does this by producing an equation containing a weighted linear combination of predictor variables, which may then be used to predict values on the continuous predicted variable. The weights produced, or regression coefficients, are calculated to ensure that the predicted values on the dependent variable are as close as possible to the actual value obtained for all cases.

In this case, it was decided to perform a regression analysis for each approach speed in turn and, using the same set of predictor variables on each occasion, assess the contribution of each of these variables and the way that these contributions change over the five different measures of speed, ie. as the vehicles approach the junction. The variables used in the analyses in which data from all four sites was included were: OTHPRES (a new variable created for these analyses which recorded the presence or absence of at least one vehicle on the site as the study vehicle reached the final zone prior to entering the junction, with a cut-off time of fifteen seconds); DENSITY (the measure of the total number of vehicles using the junction during the period of the study vehicle's passage through) and finally BEHIND and FOLLOW (the time gap between the study vehicle and, respectively, the vehicle behind and the vehicle in front). For the purpose of this, and subsequent, analyses, these latter two variables were re-coded into dichotomous variables indicating gaps over or under three seconds. This criterion was selected to conform to the findings of Rockwell (1972) as discussed in Section 2.1.1.

Other measures of speed could not be included as it was anticipated that these would be highly correlated with the dependent variable each time. As with the ANOVAs described in the previous section (4.4.1), only vehicles which did not have to queue to enter the junction were included in the analyses.

Finally, the standard technique of multiple regression (rather than others such as stepwise or hierarchical) was chosen as this is the most appropriate technique to use when the assessment of the relationships between variables is desired. Tabachnick and Fidell (1983) suggest using this technique unless there are convincing logical or theoretical arguments for the relative importance of variables prior to performing the analyses. Given the exploratory nature of the section of the research, standard multiple regression was the technique selected. For all bar two of the analyses, the recommended ideal cases-to-variables ratio (suggested by Tabachnick and Fidell) of 20:1 was easily exceeded. The analyses involving SPEED1 and SPEED5 as the dependent variables for Site 1 had ratios of just over 15:1 which may be considered to be easily acceptable given that the stated minimum requirement is 4 or 5:1.

Also in line with the previous ANOVA analyses, it was decided to perform separate analyses for each site on the first and final approach speeds. Tabachnick and Fidell suggest that the most useful measure of the predictive value of any particular variable is the semi-partial correlation coefficient (sr_i^2), which (for standard multiple regression) indicate the amount by which R^2 (the squared multiple correlation - the proportion of sums of squares for regression in the total sums of squares) would be reduced if the variable in question was omitted from the analysis. For the purposes of this stage of the research it was decided that a criterion value of 0.05 (5%) was adequate.

Table 4.10 (over) summarises the findings from these multiple regression analyses and includes the main statistics and probabilities for the overall solution. Also presented are details of any variables which produced either a beta (the standardised regression coefficients - also a useful guide to the predictive power of a variable) value over 0.3 or a semi-partial correlation coefficient over 0.05. Full details of these multiple regression analyses, along with the accompanying correlation matrices, can be found in Appendix O.

Table 4.10: Summary of Multiple Regression Analyses using Measures of Speed as the Dependent Variable

	N	Multiple R	R^2	Adjusted R^2	Probability	Variable(s)	Sr^2	Beta
SPEED1 - All sites	1725	0.099	0.010	0.008	0.002	-	-	-
SPEED1 - Site 1	61	0.273	0.075	0.008	0.353	-	-	-
SPEED1 - Site 2	665	0.129	0.017	0.011	0.026	-	-	-
SPEED1 - Site 3	809	0.145	0.021	0.016	0.002	-	-	-
SPEED1 - Site 4	182	0.459	0.211	0.193	0.000	FOLLOW	0.131	-0.368
SPEED2 - All sites	1725	0.294	0.086	0.084	0.000	OTHPRES	0.052	-0.234
SPEED3 - All sites	1725	0.280	0.079	0.076	0.000	-	-	-
SPEED4 - All sites	1725	0.233	0.054	0.052	0.000	-	-	-
SPEED5 - All sites	1725	0.379	0.144	0.142	0.000	DENSITY	0.123	-0.369
SPEED5 - Site 1	61	0.420	0.177	0.118	0.026	FOLLOW	0.127	0.348
SPEED5 - Site 2	665	0.562	0.316	0.312	0.000	DENSITY	0.242	-0.514
SPEED5 - Site 3	809	0.493	0.243	0.239	0.000	DENSITY	0.155	-0.418
SPEED5 - Site 4	182	0.593	0.352	0.337	0.000	DENSITY	0.180	-0.457
						OTHPRES	0.052	0.246

As can be seen from Table 4.10, many of the analyses produced rather poor overall solutions when the values of (adjusted) R^2 are considered. For the analyses using the data from all four sites combined, the highest value recorded was 0.142 (14.2% variance accounted for by the solution) for SPEED5, the lowest being the 0.008 (0.8%) for the SPEED1 solution. However, when the sites were analysed individually with SPEED1 and SPEED5 as the dependent variables, some of the solutions had relatively high adjusted R^2 values. Although the analyses for which SPEED1 was used as the predicted variable produced no outstanding solutions, those predicting values of SPEED5 were much more promising. In fact, the adjusted R^2 values ranged from 0.118 (11.8%) for Site 1 to 0.337 (33.7%) for Site 4 and these were generally reasonably good solutions. These findings imply that the final approach speed measured as the vehicles covered the final section of road leading up to the 'Give Way' line (or other appropriate turning point) can be predicted to some degree of accuracy using the variables included in these analyses, particularly when the sites are studied individually.

As far as the contributions of the individual variables are concerned, DENSITY, FOLLOW and OTHPRES were the only ones that accounted for relatively large amounts of variance. DENSITY (the total number of vehicles present during the study vehicle's passage through the junction) and OTHPRES were the only variables that featured in the analyses containing data from all sites. When SPEED5 was selected as the predicted variable, DENSITY was the only predictor variable for which the criterion value of 5% was reached (12.3%). OTHPRES was able to account for 5.2% of the variance in the analysis using SPEED2 as the predicted variable.

The only predictor that emerged in the analyses using SPEED1 as the DV was FOLLOW (whether the study vehicle was following the preceding vehicle with a gap of more or less than three seconds) which featured in the analysis of data from Site 4 contributing 13.1% to the overall variance of SPEED1. Once again, the analyses using SPEED5 as the predicted variable produced more promising contributing variables and whilst it may be noted that FOLLOW was the best predictor of SPEED5 at Site 1 (12.7%), DENSITY featured more than any other predictor variable in this set of analyses. This variable's contribution to the individual junction analyses ranged from 15.5% (Site 3) to 24.2% (Site 2) which can be considered large single variable contributions. An additional variable, OTHPRES, was also found to be a good predictor in the analysis of Site 4, accounting for 5.2% of the variance of SPEED5.

Although the overall solutions can be said to be disappointing in their ability to predict the various approach speed measures, the contribution of individual variables, particularly DENSITY, was relatively large in several cases.

4.4.3 Summary of Section 4.3

The comparisons of vehicles' approach speeds produced some significant results, although the analyses combining data from all four sites were the most successful in terms of high strength of association between the vehicle classes and the approach speeds. The multiple regression solutions designed to predict approach speeds produced disappointing solutions, with a maximum value of adjusted R^2 of 33.7%. The best solutions were those predicting the junction approach speed in the final segment (SPEED5), with traffic density being the most effective predictor. Following distance was found to be the only reasonable predictor of approach speed when measured during the segment furthest from the junction.

4.5: INFERENTIAL STATISTICS - SIGNALLING & SITE NEGOTIATION

4.5.1 Discriminant Function Analysis With Correct/Incorrect Signalling as the Dependent Variable

The descriptive statistics outlined earlier in this chapter revealed that many drivers do not give the correct (or sometimes any) indication for their intended exit from the junction and it was felt that this warranted further investigation. It is argued that it would be useful to be able to uncover which variables, if any, were able to discriminate between drivers who were observed to use the appropriate indication from those which did not.

Discriminant Function Analysis (DFA) is similar to multiple regression in that it is a statistical technique that calculates the extent to which a number of predictor variables are able to predict scores on another, dependent variable. The main difference is that the predicted variable in DFA is categorical, and the object is to find the weighted linear combination of predictor variables that best discriminates between levels of the predicted variable. In this example, the variable that relates to a drivers' indicating activities at a junction (INDIC) can be reduced to a simple dichotomous variable: the two levels being correct and incorrect signalling for the lane positioning and exit used (the new variable being labelled CORRSIG). The data for all four junctions were combined as the main objective of this section was to uncover any general principles that relate to signalling. However, separate analyses were then performed on the individual sites to uncover any effects specific to one site.

The variables included were identical for all five analyses in this section and were: FOLLOW; BEHIND; QUEUE1 (the presence or absence of a queue at the 'Give Way' line or equivalent); QUEUE2 (the presence or absence of a queue behind the study vehicle as it reached the 'Give Way' line); TOTTIME (an approximate measure of the total amount of time it took each vehicle to negotiate the junction); OTHPRES (the presence or absence of a vehicle on the main section of the junction during the study vehicle's approach and negotiation); SPEED1; SPEED5; DENSITY; TRAKSITE; and STOP (whether or not the vehicle stopped at the entrance to the junction).

The standard version of DFA, in which all variables are included in the solution simultaneously, was selected as there was no theoretical basis upon which to order the predictor variables. Tabachnick and Fidell (1983) suggest that having a large sample size ensures that an analysis is sufficiently robust, and it is argued that the sample sizes for these analyses are well within the acceptable range. Certainly, the case-to-variable ratios are above the minimum acceptable ratio suggested by Tabachnick and Fidell (op.cit.) of 4:1, although the ratio for the analysis of Site 1 was exactly 4:1. The remaining analyses achieve at least a 10:1 ratio, and the ratios for the analyses for all sites and also Site 4 individually were over the 20:1 ideal.

The potential problems of multicollinearity (when two or more variables are near-perfectly correlated and have highly similar correlations with other variables) and singularity (when one variable is a linear combination of other variables) can be dismissed as the DFA program used assesses variables for each effect and fails to include any variables which do not meet the tolerance value into the solution.

An additional point that should be considered is that uneven sample sizes were found in the two groups of the dependent variable in all analyses due to the fact that drivers were observed to give far more correct than incorrect direction signals. Although these uneven samples can have serious effects on the outcome of an analysis, SPSS is able to take such imbalances into account. However, it is argued that having hugely discrepant group sizes still makes the final classification matrix difficult to interpret and therefore it was decided to take random samples from the over-represented group for each analysis to produce roughly even sample sizes in each group of the predicted variable.

The standardised canonical discriminant function coefficients are the weights for each variable included in the solution which, when combined with each other, form the best linear combination of variables from which the value of the dependent variable can be predicted. However, a more accurate measure of the predictive value of variable is given by its' pooled within-groups correlation coefficient, although Tabachnick and Fidell (op.cit.) point out that these values do not necessarily indicate which variables are the best discriminators when adjustment for the impact of the other variables is made. As a fairly rough guide, they are useful and it is suggested that a criterion value of 0.30 (ie. 9% variance accounted for) be used. In addition, the squared semi-partial correlation coefficients (sr_i^2) provide an indication of the percent of variance contributed by each significant predictor.

Table 4.11 (over) summarises these DFA analyses, giving the eigenvalue (the total amount of variance consolidated from the correlation matrix), canonical correlation coefficient (the relationship between the discriminant scores and group membership) and the percentage variance accounted for by the solution along with details of any variables which were found to have a pooled within-groups correlation coefficient in excess of 0.30. Full details of these analyses can be found in Sections P.1 to P.5 of Appendix P.

Table 4.11: Summary of Discriminant Function Analyses using CORRSIG as the Predicted Variable

DFA Solution:	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Variable(s)	Pooled Within-Groups Correlation Coefficients
All Sites	0.113	0.319	10.18	0.000	63.87	SPEED5	0.742
(N=786)						TRAKSITE	0.593
						QUEUE1	-0.580
						TOTTIME	-0.528
						DENSITY	-0.421
						QUEUE2	-0.408
						FOLLOW	-0.331
Site 1	0.231	0.433	18.75	0.658	54.55	QUEUE2	0.404
(N=44)						DENSITY	0.379
						STOP	0.326
						OTHPRES	0.324
Site 2	0.093	0.292	8.53	0.463	60.00	DENSITY	0.667
(N=135)						TOTTIME	0.658
						STOP	0.480
						QUEUE2	0.447
						SPEED5	-0.447
						BEHIND	0.444
						SPEED1	-0.443
						QUEUE1	0.326
Site 3	0.138	0.348	12.11	0.003	65.07	SPEED5	0.646
(N=209)						DENSITY	-0.404
						SPEED1	0.353
						TOTTIME	-0.308
Site 4	0.105	0.308	9.49	0.005	59.53	SPEED1	0.910
(N=257)						FOLLOW	-0.456
						TOTTIME	-0.327

The solutions produced are all fairly similar in their ability to discriminate between values of CORRSIG. The amount of variance accounted for by each of the solutions ranged from 8.5% (Site 2) to 18.7% (Site 1). The analysis which combined data from all sites was found to explain a disappointing 10.1% of the variance of CORRSIG. By default this means that the particular combination of variables used could not account for almost 90%. Whilst it appears that the solution for Site 1 produced the most promising result in terms of variance accounted for, it should be remembered that this analysis had a relatively poor case-to-variable ratio and therefore the analysis should be treated with caution. Indeed, both this and the Site 2 analyses were not significant, whilst the remaining analyses, including the combined analysis, were significant beyond the 1% level.

Each of the solutions were able to classify correctly around 60% of all cases. It should be noted that a hit rate of 50% would be expected given that CORRSIG is a dichotomous variable and, using the binomial theory, it can be shown that a success rate of 65.07% (achieved for the Site 3 analysis) produces a z-score of 4.36 with a one-tailed probability of less than 0.1%. In other words, the chances of obtaining this number of correctly-classified cases by chance is less than 0.1%, suggesting that the solution produced is a useful predictor of signalling practices. The overall solution correctly classified almost 64% of cases, the solution with the lowest correct classification rate was that for Site 1 with only 54.55% correct (giving a z-score of 0.60 and a probability of 0.284).

As far as the contributions of individual variables to each of the solutions are concerned, no strong patterns emerged. The overall solution produced seven variables that reached the criteria chosen to highlight good predictor variables, the maximum pooled within-groups correlation coefficients achieved was 0.74 (SPEED5). The analysis of Site 4 produced the variable contributing the most to the solution, SPEED1 having a within-groups correlation of 0.91. The analyses of Sites 1 and 2 were disappointing with no variables claiming correlations of more than 0.7 In the former analysis, QUEUE2 was most prominent (0.40) whilst TOTTIME and DENSITY both achieved around 0.66 in the analysis for the latter site.

It must be concluded that this series of analyses was largely unsuccessful in its attempt to uncover factors associated with correct and incorrect signalling behaviours. The combination of variables used was not able to offer satisfactory solutions, whether the four sites were combined or treated individually, and no strong predictors were found amongst the independent variables.

4.5.2 Discriminant Function Analysis With Correct/Incorrect Tracking as the Dependent Variable

In a similar fashion to the previous series of analyses, it was decided to investigate the problem of site tracking, another factor that emerged from the earlier sections of the observation study. The form of discriminant function analysis that was selected was identical to that used in the previous section. The predicted variable on this occasion was TRAKSITE, originally coded as a dichotomous variable: correct and incorrect site negotiation. The list of independent variables included in this section corresponded with those used in the previous series of analyses, the only exception being the use of CORRSIG as a predictor variable in this section in place of TRAKSITE. Once again, random samples of cases from the over-represented correct tracking group were taken to ensure reasonably equal sample sizes in the two groups.

In addition to an analysis combining data from all four junctions, individual analyses were once again performed for each site in turn. However, it can be seen that Table 4.12 (over) only contains details of the overall analysis and those carried out on data from Sites 2 and 3. This is due to the fact that, once cases with missing values had been deleted from the analyses of Sites 1 and 4, there were too few cases remaining in the incorrect tracking category to perform reliable analyses. It may be remembered that, due to impaired visibility, only details of vehicles turning left could be recorded at Site 2.

Unfortunately, this also means that the analysis using data from all four sites almost exclusively contains cases from the Site 3 analysis in the incorrect tracking group. However, it has already been pointed out that the analysis contained within Sections 4.4 to 4.6 should be treated with a certain amount of reservation and it is argued that the analyses may be useful in providing suggestions for the direction of any further research in this area. Full details of the analyses contained within this section can be found in Sections P.6 to P.8 of Appendix P.

Not surprisingly, the analyses for all sites and Site 3 outlined above produced some similar results. It has already been pointed out that the incorrect tracking group will contain mainly cases from Site 3, but it should be noted that, due to the random sampling of cases in the correct tracking group, the cases in this category will be drawn from each of the four sites.

Table 4.12: Summary of Discriminant Function Analyses using TRAKSITE as the Predicted Variable

DFA Solution:	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probab- ility of Function	% Cases Correctly Classified	Variable(s)	Pooled Within-Groups Correlation Coefficients
All Sites	0.310	0.486	23.62	0.000	70.07	SPEED5	0.631
(N=558)						CORRSIG	0.597
						TOTTIME	-0.548
						DENSITY	-0.478
						QUEUE1	-0.477
						QUEUE2	-0.444
Site 2	0.247	0.445	19.80	0.105	60.87	SPEED5	-0.694
(N=92)						DENSITY	0.675
						QUEUE1	0.666
						QUEUE2	0.666
						TOTTIME	0.489
Site 3	0.172	0.383	14.67	0.000	67.99	SPEED5	-0.838
(N=478)						TOTTIME	0.828
						DENSITY	0.713
						QUEUE2	0.375
						STOP	0.348
						QUEUE1	0.317
						FOLLOW	0.304

The total amount of variance accounted for by the overall solution was a quite respectable 23.7%, whilst the two individual analyses produced equivalent figures of only 19.8 and 14.7%. In all cases, the number of cases correctly classified by the solutions were over 60%, with the overall solution scoring over 70% which may be considered to be very high given the sample size (the equivalent z-score being 9.48 - $p<0.000$). However, it is worth noting that, whilst the overall and Site 3 solutions proved to be significant beyond the 0.1% level, the Site 2 analysis was not found to be significant.

The similarity between the analyses was found to be most noticeable when the efficiency of the discriminating variables were considered. Indeed, five of the eight significant discriminators were common to all solutions. Of these IVs, SPEED5 was found to be the best discriminator for all solutions, achieving pooled within-groups correlation coefficients of between 0.63 and 0.84. In all examples, vehicles that were observed to negotiate the junctions in an inappropriate manner were also found to have a greater terminal speed (ie. SPEED5) prior to entering the junction (see Tables P.6.1, P.7.1 and P.8.1 in Appendix P). DENSITY and TOTTIME also featured quite prominently as good discriminators, the former having a within-groups correlation of 0.71 for the Site 3 analysis, the latter 0.83 for the same analysis. This indicates that vehicles tend to negotiate the junctions more accurately when traffic is more dense and when more time is taken to execute the entire manoeuvre. QUEUE1 and QUEUE2 both featured in all analyses, and it appears that more correct-tracking than incorrect-tracking vehicles encountered queues of traffic in front and behind when at the junctions.

Overall, it can be said that the solutions offered in this section are generally more satisfactory than those used to predict correct and incorrect signalling behaviour in the previous section. The contributions of predictor variables were fairly consistent over the series of analyses, as were the number of cases correctly classified by the solutions. However, it should be remembered that many reservations about the validity of these analyses were stated, and these should be taken into account when these results are considered.

4.5.3 Summary of Section 4.5

The discriminant function analyses performed to discriminate between correct and incorrect use of direction indicators produced inconclusive results, with the solutions for different sites showing no overall consistency. The equivalent series of analyses discriminating between correct and incorrect site tracking generally produced much better solutions, and vehicles' final approach speeds, traffic density and the total time required to negotiate the junction emerged as good predictors. Vehicles that were observed to correctly negotiate a junction were found to generally have a lower final approach speed and take longer to complete the manoeuvre, whilst traffic in these cases was generally heavier.

4.6: INFERENTIAL STATISTICS - TRAFFIC CONFLICTS

4.6.1 Relationship Between Conflicts & Accidents at the Four Junctions

One of the main features of the observation study was the inclusion of variables relating to traffic conflicts and, before the main inferential tests concerning the conflicts are discussed, it was felt that it would be useful to examine the relationship between traffic conflicts and accidents at the sites covered by the observation study. Spicer (1972) is one of a number of researchers who has examined such a relationship and found positive evidence for a link between accidents and related conflicts (ie. those resulting from a similar manoeuvre). Indeed, some of the correlation coefficients obtained by Spicer exceeded 0.90 for accidents and serious conflicts. However, a serious problem with this approach is that actual collisions were treated as very serious conflicts, and therefore the two sets of figures could not be considered to be truly independent. A further problem is that, whilst traffic flow was correlated with both accidents and conflicts, producing non-significant results, this factor was never taken into account in the comparisons between accident and conflict rates (Spicer, 1973).

Therefore it was decided to investigate the effect of traffic flow as a co-variate by using the partial correlation technique in which the influence of a third variable is partialled out of the comparison between the other two variables. Table 4.13 (over) shows the bivariate correlation coefficients for each combination of the variables measuring number of accidents, number of conflicts and traffic flow when broken down by approach road. In addition, the partial correlation between accidents and conflicts with the effect of traffic flow removed are also shown. It should be noted that, unlike Spicer who used only serious conflicts in his comparisons, these figures include all types of conflicts as very few serious conflicts were recorded in this study. In addition, separate analyses for each of the sites were performed along with analyses including data from all four sites. Finally, as only half of the data for Site 2 was analysed, the traffic flow and conflict figures were doubled for this analysis to retain consistency with the others. It should be noted that, in all cases, the first set of figures in parentheses are the squared correlation coefficients (ie. the percentage of variance accounted for) whilst the second set relate to the associate probabilities of the results.

Table 4.13: Correlations Between Number of Accidents, Number of Traffic Conflicts and Traffic Flow Rates for the Sites: Collectively and Individually

Site:	Correlation Coefficient for Accidents & Conflicts	Correlation Coefficient for Accidents & Traffic Flow	Correlation Coefficient for Conflicts & Traffic Flow	Partial Correlation Coefficients (Effects of Traffic Flow removed)
All	0.408 (16.6%) (p>0.05)	0.326 (10.6%) (p>0.05)	0.780 (60.9%) (p<0.01)	0.260 (6.8%) (p>0.05)
1	0.757 (57.3%) (p>0.05)	0.250 (6.2%) (p>0.05)	-0.383 (14.6%) (p>0.05)	0.953 (90.9%) (p<0.05)
2	0.270 (7.3%) (p>0.05)	-0.053 (0.3%) (p>0.05)	0.904 (81.8%) (p<0.05)	0.745 (55.4%) (p>0.05)
3	0.472 (22.2%) (p>0.05)	0.704 (49.5%) (p>0.05)	0.953 (90.7%) (p<0.01)	-0.924 (85.5%) (p<0.05)
4	0.595 (35.4%) (p>0.05)	0.941 (88.5%) (p<0.01)	0.697 (48.6%) (p>0.05)	-0.251 (6.3%) (p>0.05)

As Spicer found, the correlations between accidents and traffic flow were generally quite poor, although the comparisons for Sites 3 and 4 produced high values of 'r' (0.704 and 0.941 respectively), the latter accounting for almost 90% of the variance and the only one to achieve significance. However, the correlations between conflicts and traffic flow proved to be mainly excellent, with only the comparison for Site 1 producing a coefficient below 0.6. In fact, this comparison revealed a small negative relationship between the two variables. The analyses for Sites 2, 3 and all sites revealed that over 60% of the variance could be accounted for and all were found to be significant beyond the 5% level.

The bivariate correlations between accident and conflict rates produced low 'r' values with only the analyses for Sites 1 and 4 producing a result that accounted for over 30% of the variance (57.3 and 35.4% respectively), none of these correlations being significantly high. However, the partial correlations reveal a confusing pattern, with three of the four individual site tests (all bar the analysis for Site 4) revealing strong relationships, although only the analyses for Sites 1 and 3 produced significant values of 'r'. Indeed, each of these three analyses produced coefficients that accounted for over 55% of the variance - the most impressive being the analyses using data from Site 1 which accounted for 90.9%. However, it should be noted that the Site 3 result differed from the others in that it produced a high negative correlation rather than a high positive one. The remaining single site (4) analysis and all-sites analysis showed a weak negative and a weak positive relationship respectively between accidents and conflicts with the effects of traffic flow removed.

4.6.2 Discriminant Function Analysis using Traffic Conflicts as Dependent Variable - Two Factor Solution

Following on from Grayson and Hakkert's (1987) recommendation that one of the ways forward for traffic conflicts studies was to use the conflicts themselves as dependent variables in such studies, analyses were carried out to determine which, if any, variables were able to usefully discriminate between conflict-involved and non-conflict-involved vehicles.

It may be remembered (see Section 4.2.3) that conflicts were divided into two major categories, and it was decided that it would be most appropriate if the data were combined into a two-factor DFA with three groups: vehicles involved in each of the two conflict types and vehicles not involved in any form of conflict. However, additional separate analyses were performed on each of the two conflict categories, in both cases contrasting conflict-involved vehicles with non-conflict-involved vehicles. Full details of these additional analyses, along with the complete tables from the two-function solution, can be found in Section P.9 of Appendix P. In all cases, the data from all four sites were combined due to the relatively low number of conflicts, particularly those of the rear-end variety at some sites.

Table 4.14 (over) reviews the analysis in which 15 independent variables were used in an attempt to obtain a solution that was able to discriminate between vehicles involved in left-turn conflicts, rear-end conflicts and those not involved in any form of conflict. It should be noted that this analysis did not include the 14 cases of vehicles involved in cross-traffic conflicts as it was felt that combining these cases with those involved in left-turn conflicts would be assuming too much correspondence between these forms of conflict when none can be shown to exist. There was no prior theoretical model upon which to base the decision to include certain independent variables in the solution, and therefore selection was determined partly on logical grounds. The variables included were: FOLLOW; BEHIND; QUEUE1; TOTTIME; OTHPRES; SPEED1; SPEED5; DENSITY; TRAKSITE; QUEUE2; STOP; CORRSIG; SIDE; DECEL (an estimation of a vehicle's rate of change of approach speed over the first two approach segments) and finally, NEWPULL. This latter variable is similar to Allen, Shin and Cooper's (1978) notion of gap time (GT) (outlined in Section 2.2.3) and discriminated between vehicles which pulled out onto the junction with over 5.4 seconds to spare before the next on-site vehicle arrived at the potential point of impact and those found to have an equivalent gap under this threshold. This criterion was selected on the basis of the findings of Tsongos and Weiner (1969) who found that the mean gap accepted by drivers was 5.4 seconds for daytime driving (see Section 2.1.2).

Table 4.14: <u>**DFA Analysis with Type 1 Conflict/Type 2 Conflict/No Conflict as DV**</u>

DFA Solution: (N=136)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Variable(s)	Pooled Within-Groups Correlation Coefficients
Function 1	2.262	0.833	69.35	0.000		QUEUE1	0.627
						OTHPRES	0.451
						NEWPULL	-0.450
						FOLLOW	0.395
					79.41		
Function 2	0.459	0.561	31.44	0.000		OTHPRES	0.611
						NEWPULL	-0.553
						QUEUE1	-0.528

The table shown above reveals that the two functions produced by the solution could account for a very respectable 69.4% and 31.4% of the variance of the predicted variable, TYPECON. In addition, almost 80% of the 136 cases were correctly classified by the solution. Applying the binomial theory to this figure translates it into a z-score of 11.40, with an accompanying one-tailed probability of less than 0.1%, a highly significant result. The case-to-variable ratio in this example was 9:1, which is above the accepted minimum ratio of 4:1 suggested by Tabachnick and Fidell (op.cit.).

Figure 4.1 (over) plots the group centroids for the two functions. This clearly reveals that the first function discriminates between the two forms of conflict, with non-conflict cases effectively scoring zero on Function 1. The second function discriminates between non-conflict-involved vehicles and those involved in both forms of conflict.

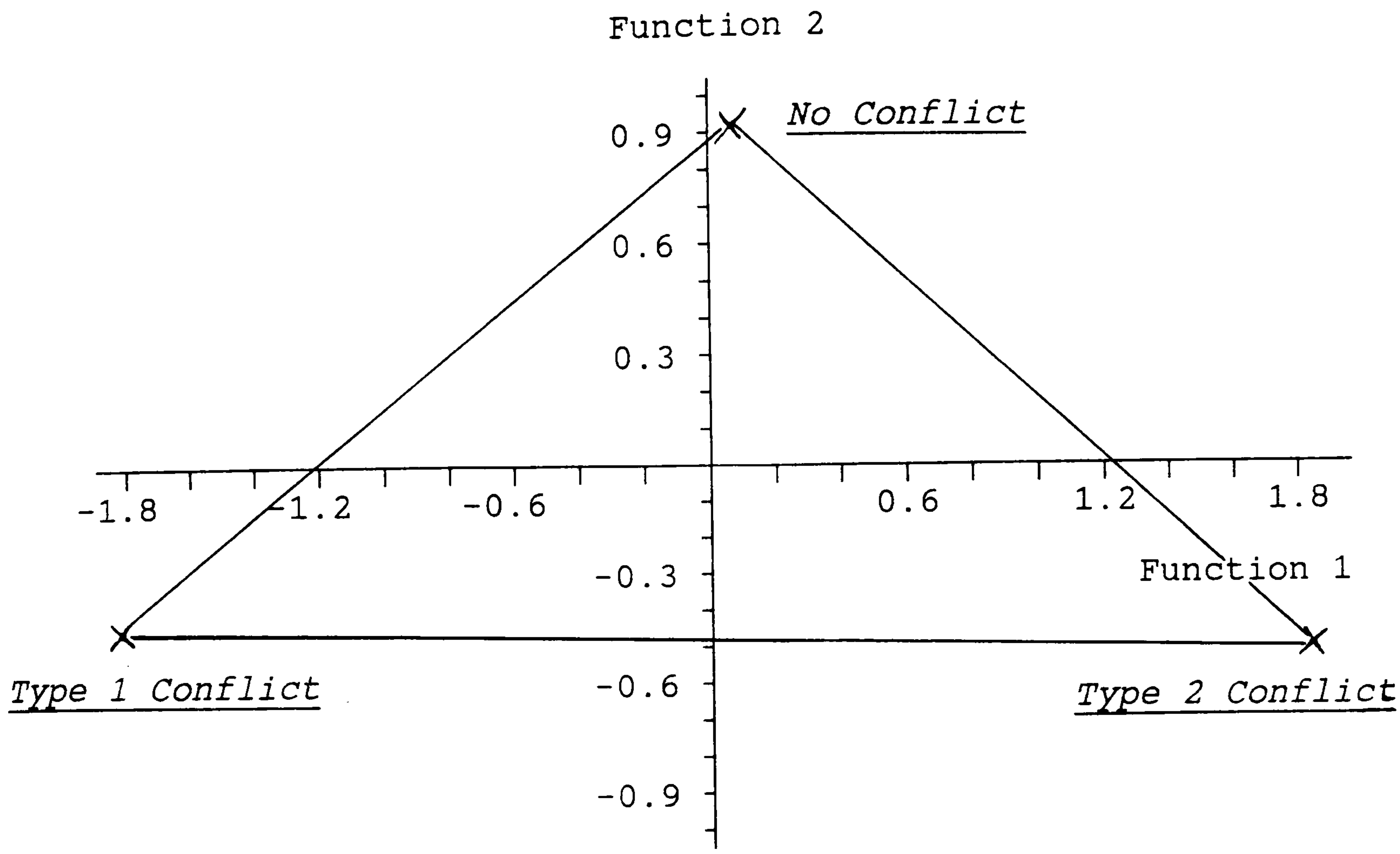

Figure 4.1: **Group Centroids for DFA to Predict Involvement in Traffic Conflicts**

When the contributions of the independent variables to the two functions are considered, it was found that several of the variables were good discriminators for both functions. QUEUE1 was the single variable contributing most to the solution, with pooled within-groups correlations of almost 0.63 and -0.53 on the two functions respectively. The direction of the scores indicate that more drivers involved in Type 2 conflicts were faced with a queue at the entrance to the junction, and also that those involved in Type 1 conflicts encountered a queue least often.

Two other variables, OTHPRES, and NEWPULL, were all found to be good discriminators in both functions. The means for the three groups show that: Type 2 conflict-involved vehicles encountered a vehicle on-site as they entered Sector 5 more often than Type 1 conflict-involved vehicles; and, Type 1 conflict-involved drivers were more likely to pull out onto the site with a gap of less than 5.4 seconds, Type 2 conflict drivers as likely to perform this manoeuvre as the non-conflict-involved drivers. The only other good discriminator between the two conflict types (ie. on Function 1) was FOLLOW. The means indicating that, respectively, vehicles involved in Type 2 conflicts were more likely than Type 1 conflict-involved vehicles to follow the vehicle in front with a gap of under 3 seconds.

4.6.3 Discriminant Function Analyses using Traffic Conflicts as Dependent Variables - Single Factor Solutions

The individual analyses described in Appendix P produced some similar findings. The analysis discriminating between Type 1 conflict-involved vehicles and vehicles not involved in any form of conflict revealed STOP (whether the vehicle stopped at the 'Give Way' line) (4.1% variance accounted for), QUEUE1 (3.0%) and SPEED1 (approach speed in the sector furthest from the junction) (2.3%) to be the best discriminating variables. The type 2 conflict analysis showed QUEUE1 (the presence of a queue of traffic waiting to enter the junction) (18.5%) and FOLLOW (following distance) (18.5%), along with DENSITY (traffic density) (6.5%), to be the most effective discriminators. Both solutions were exceptionally good in terms of correctly-classified cases (71.75% for the Type 1 solution, 81.31% for the Type 2 solution).

Overall, the discriminant function solutions produced in this section proved to be highly satisfactory in their ability to discriminate between conflict types and non-conflicts, being able to correctly classify a very high proportion of cases. Additionally several variables, particularly that noting the presence of a queue at the 'Give Way' line (QUEUE1), were found to be excellent discriminators.

4.6.4 Summary of Section 4.6

The DFA solution used to predict conflict involvement produced extremely good overall solutions, which were able to correctly classify a significantly high proportion of cases. The results of the three-group solution suggested that drivers involved in rear-end shunt conflicts were more likely to have been faced with a queue at the 'Give Way' line, whilst drivers of left-turn conflict-involved vehicles were found to enter the junction with gap times (before the arrival of an on-site vehicle) of less than 5.4 seconds more often.

In the two-group solutions, the best predictors of left-turn conflicts were found to be those measuring queuing behaviour and first segment approach speed, these conflict-involved vehicles encountering a queue less often and having a greater initial approach speed. The rear-end analysis emphasised the excellent predictive capacity of the variables measuring queuing, following distance and traffic density. The signs suggested that these conflict-involved drivers encountered a queue more often, adopted smaller following distances and were in heavier traffic.

4.7: SUMMARY OF RESULTS - STUDY 1

One of the most striking factors that emerged from the observation study was the high proportion of drivers who fail to signal when negotiating junctions, particularly drivers turning left. At Sites 1 and 4, it was noted that the absence of signalling was considerably worse in vehicles turning from minor into major roads than vice versa.

Assessments of the contributions of a variety of variables to approach speeds, signalling behaviour and junction negotiation were made. The comparisons of vehicles' approach speeds produced significant results, although the site-specific tests were not as successful as those which combined the data from all four sites. The multiple regression solutions designed to predict approach speeds produced disappointing solutions, with a maximum value of adjusted R^2 of 33.7%. The best solutions were those predicting SPEED5, with traffic density being the best predictor.

The discriminant function analyses performed to discriminate between correct and incorrect use of direction indicators also produced inconclusive results with the solutions for different sites showing no overall consistency. The equivalent series of analyses discriminating between correct and incorrect site tracking generally produced much better solutions, and final approach speed (greater for poor negotiators), traffic density (higher for good negotiators) and time to negotiate the junction (shorter for poor negotiators) emerged as good predictors.

The DFA solution used to predict conflict involvement produced extremely good overall solutions, able to correctly classify a significantly high proportion of cases. At least 60% of conflicts at each site were of the left turn type (ie. a vehicle pulling out into the path of another vehicle), increasing to 85% for Site 3. At Sites 1 and 4 these all happened to vehicles pulling out from a minor road onto a major road. The fact that none of these conflicts were observed to be a result of manoeuvres made by vehicles at Site 4 travelling North and turning from the major into the minor road is of interest as this was the dominant source of accidents at that site. The best predictors of these left-turn conflicts were found to be: the presence or absence of a vehicle on the junction as the study vehicle entered the final approach segment before entering the junction (presence more likely to result in this form of conflict); and whether or not the study vehicle pulled away from the 'Give Way' line with more than fifteen seconds to spare before an on-site vehicle arrived at the junction entrance (the conflict-involved drivers more likely to accept the shorter pull-out time).

The rear-end-shunt-type conflict accounted for the vast majority of the remaining conflicts at all four sites. Most of these conflicts at Sites 1 and 4 occurred as vehicles queued on the major road, waiting to turn into a minor road. The presence of a queue at the 'Give Way' line (or equivalent) was the best predictor of involvement in this type of conflict, being more likely to occur in the presence of such a queue. The following distance between the study vehicle and the vehicle in front was also found to be a good predictor - the shorter the following time, the greater the likelihood of involvement in a rear-end shunt conflict.

The only vehicles involved in significantly more conflicts than expected were motorcycles, but it should be noted that the low numbers of such vehicles involved prevent any reliable conclusions being made. The two roundabouts accounted for proportionally more conflicts than the other two sites, but rather than implicating this junction style, the difference may be due to other factors such as traffic flow or vehicle-type distribution.

CHAPTER 5:

DISCUSSION OF STUDY 1 RESULTS

5.0: OVERVIEW

The previous chapter presented the results of the analyses performed on the data gathered from the observation study, and the purpose of this chapter is to discuss the findings and place them in context. Section 5.1 covers the descriptive statistics reported, discussing them in a site-by-site manner and relating the information to the accident records presented in Chapter 3. Although it was pointed out at the beginning of Section 4.4 that the inferential tests performed on the data should be treated with some degree of reservation, these analyses must still be discussed, and Section 5.2 deals with this.

The accident records and conflict analyses highlighted three major classifications of driver error at junctions. Each of these is briefly discussed in Section 5.3, particularly in relation to the relevant previous research. Section 5.4 provides a comprehensive assessment of the methodology adopted in this study, including sections on the use of the observation technique, the adequacy of the sampling strategy employed, and the adoption of the traffic conflicts technique as a tool for diagnosing problems at junctions. Finally, Section 5.5 contains a summary of the major points of discussion from this chapter before laying the foundations and suggesting the direction for the second study.

5.1: DISCUSSION OF DESCRIPTIVE STATISTICS

5.1.1 Descriptive Statistics for Site 1

The rural nature of this junction makes it likely that a large proportion of users during the morning and evening sessions were commuters, and it is therefore not surprising that over half of the total number of vehicles observed at this site occurred during these two periods. The absence of a lunchtime peak may be due, at least partly, to the distance of the junction from the main centres of employment in the area, thus making it difficult for the commuters to drive home for lunch. Perhaps the most notable feature of the distribution of vehicle types at this junction was the relatively high proportion of light goods vehicles and almost complete absence of heavy goods vehicles. However, it should be noted that the low incidence of the latter class of vehicle is due to the restrictive weight limit imposed upon vehicles travelling through this junction. The higher number of light goods vehicles may be a consequence of the small-scale construction sites in the vicinity of the junction. In addition, the relatively large proportion of bicycles is likely to be common to such rural locations.

The percentage of vehicles involved in traffic conflicts at the site was lower than at any other junction studied, with a non-conflict to conflict ratio of 18.5:1 compared to a mean of 14:1 for the other three junctions. However, it is interesting to note that none of these conflicts were classed as 'severe' and it is speculated that this may be a function of the lower traffic flow noted at this site.

It may be remembered from the accident history of Site 1 (outlined in Section 3.1.5.3) that details of a mere nine accidents were available for analysis. The most common form of accident at this junction involved vehicles approaching along a minor road (that coming from the South-East) pulling out into the path of vehicles travelling along the main road through the junction. The list of traffic conflicts for this junction in Table I.5 (Appendix I) reveals that almost 40% of all conflicts were of an equivalent nature to this form of accident (ie. where evasive action was necessary as a result of a vehicle entering the site and encroaching upon the path of a vehicle travelling through the junction), referred to as the left-turn conflict. In fact, of all the conflicts of this variety, almost three-quarters were at this entrance to the junction. This correspondence between accidents and observed conflicts is encouraging from the point of view of assessing dangerous locations, and in this case suggests that some drivers are having serious problems when approaching the junction from the South-East. However, it must be pointed out that considerably more vehicles used this junction entrance (70.2% of all minor-road approaching vehicles) and so the effect is not as significant as it may at first appear. Despite this, the number of conflicts and accidents is still fairly high and, at this point, it may be useful to consider other aspects of this junction approach.

From Table I.2 in Appendix I it can be seen that the approach speeds for this entrance were little different from those recorded for the opposite (North-West) entrance, all being slightly slower. Similarly, the tracking behaviour of these drivers was extremely good, with only a few examples of an incorrect path taken. However, it may be significant that signalling behaviour of the South-East approaching drivers was particularly poor. Almost half (46.2%) of all left-turning drivers approaching from this direction gave no signal at all and the vast majority (88.2%) of drivers travelling straight across the junction (ie. to the staggered North-West entrance) also failed to give the correct left signal immediately followed by a right. It should be clear that it is essential to provide fellow drivers with information about intended directions when negotiating a junction, and failure to do so must inevitably lead to near-misses, and accidents, on some occasions. However, it is hard to imagine how the absence of a direction indication in a vehicle waiting to enter the junction at a minor road affects the progress of another driver travelling along the main road through the junction. For an incident to arise, it still requires that the driver of the former vehicle to make the move by entering the junction in the path of the latter.

Clearly, there must be other forces in operation in such circumstances. As noted in Section 2.1.3, the presence of a small sight distance on the approach to a junction is often a factor that may lead to the occurrence of such incidents as those described here. Indeed, the view to the right for drivers using the South-East approach at this junction includes a somewhat restricted view, due to the presence of a high wall, for all bar the final few metres leading to the 'Give Way' line. It is possible that many of the conflicts, and possibly accidents, occurring at this site may be a consequence of this restricted sight distance.

The other main category of accident and conflict noted at other sites, the rear-end shunt, did not feature very prominently in the accident records of Site 1, with only one of the nine known accidents resulting from this kind of manoeuvre. It is quite surprising, therefore, to discover that almost half (42.9%) of the conflicts at this site were of this nature, over half of them occurring as vehicles approaching from the South-West queued on the main road to turn right into the South-East road - the configuration responsible for the single accident of this type. A surprisingly low number (one out of nine) occurred on the minor approach roads, the South-East entrance providing this solitary example. Analysis of the mean approach speeds for vehicles at this junction in Table I.2 shows a steady increase in speeds for vehicles approaching along the main road from the South-West.

It has been noted elsewhere that this the expected constant speeds for vehicles travelling straight through the junction are confounded by those vehicles turning off into one of the minor roads. If this is taken into account, it can be seen that those vehicles progressing straight through the junction are doing so at a mean speed somewhere in the region of 40mph. The relatively high standard deviations for these speeds suggests that many vehicles are travelling at speeds in excess of this, and it is perhaps not surprising that the presence of a queue of traffic waiting to turn into a side road will occasionally produce some evasive action in, or indeed a collision with, one of these speeding vehicles.

In fact, the five vehicles involved in rear-end conflicts approaching from the South-West were found to have a lower mean initial approach speed (SPEED1) value than non-conflict-involved vehicles (see Section Q.1 in Appendix Q). Although this relatively large difference did not prove to be significant (if a 5% criterion level is used), the figures are noticeably different, with the mean speed of non-conflict involved vehicles being greater than that of the rear-end conflict-involved vehicles. However, this should not be so surprising given that the situations in which there is a queue of traffic waiting to enter the side road and those where no queue is found are very different. It is likely that the conflict-involved drivers began their braking before entering the view of the camera (ie. during the first segment), but still did not begin this early enough to prevent evasive action being necessary.

For both of the types of accidents or conflicts that appear to be most prevalent at this junction, there are solutions which may be able to reduce the number of incidents. The re-design of the wall restricting the sight distance at the right of the South-East entrance and the introduction of some speed-reduction measure (such as speed humps) for vehicles passing straight through the junction would seem to be the most obvious solutions. However, it may be remembered from Section 1.3.3 that the case for engineering countermeasures is unproven, and that any changes in behaviour may be a reaction to a novel environment and therefore short-lived in effectiveness.

5.1.2 Descriptive Statistics for Site 2

The distribution of vehicles over the five time periods at Site 2 reveal a conventional pattern, with the morning and evening periods showing distinct peaks and the lunchtime period a slightly less-pronounced peak. The fact that more vehicles were observed during the morning session than during the evening session may be caused by some commuters choosing alternative routes to drive to and from work as Milton Keynes offers a wide variety of potential routes from any one point to another. The relatively high proportion of cars observed at this junction will be aided by the fact that the city is a business, rather than industrial, centre, and it is suggested that a large percentage of drivers using this junction will be on official business. Certainly, this junction forms part of one of the major routes from the busy A5 to the city centre.

The observation study revealed that the non-conflict to conflict ratio was 13.1:1, the lowest of any of the sites studied. However, the differences between this and the other sites observed are very small and it may be that the figure of approximately 7% of all vehicles become involved in conflicts at junctions may be fairly constant across all sites (see also Clube, 1979).

Of the 22 accidents at the junction for which details were available, 59.1% were of the rear-end shunt variety. Unfortunately, the approach roads for only seven of these accidents could be specified, the North entrance accounting for over half. Perhaps the most notable aspect of the rear-end conflicts observed at this roundabout is the high proportion (92.3%) occurring on the entrance road rather than on the junction itself. Over half of these conflicts occurred at the West entrance, an equal number in the inside and middle lanes, whilst all other entrances accounted for 4 rear-end conflicts each. As with Site 1, this may not be as surprising as at first it appears, as the West entrance accounted for far more vehicles (37.5%) than expected. The approach speeds of vehicles using this entrance, and particularly the inside and middle lanes, are virtually no different from those observed at other entrances at this site, although the final segment speeds (SPEED5) are slightly greater. Of more significance may be the high proportion of drivers adopting following distances under the three second criterion. Almost a third (31.4%) of drivers approaching from the West in the inside lane had a gap time of less than than three seconds, whilst just under half (45.9%) of drivers using the middle lane had equivalent following distances.

This form of conflict surely arises from drivers' lack of attention to vehicles in front, possibly compounded by excessive approach speeds in many cases. However, it may be that expectation factors play some part in these conflicts. Some drivers queuing behind another to enter the junction may often anticipate the actions of the driver at the 'Give Way' line and, assuming that driver will pull out onto the roundabout at a certain point, also move forward. If they are wrong, a collision or near-miss may result. This clearly depends upon the driver behind imposing their 'pull-out' criterion (ie. constituting what is and what is not an acceptable gap in the traffic in which to pull out) on the driver actually having to make the decision. The latter driver may often display a certain amount of indecision in this pull-out process, and it could be that a high number of the rear-end conflicts may be accompanied by a similarly large number of left-turn conflicts.

Certainly, more left-turn conflicts occurred at the West entrance than at any other (38.1%), although this figure is equivalent to the proportion of vehicles observed using this entrance. The other entrance accounting for a relatively large proportion (although still only around 25%) of the total number of vehicles using this roundabout, the North entrance, also accounted for a relatively high number of left-turn conflicts (28.6%). These apparent correspondences between traffic flow rates and conflict occurrence are confirmed by the analyses reported in Section 4.6.1 which quotes a correlation of 0.9 (81.8% variance accounted for) between these figures for Site 2.

However, the factors in operation causing these conflicts are hard to determine. The sight distance at this entrance is roughly the same as that at each of the other three entrances but the large central island covered in vegetation means that drivers are unable to determine whether any vehicles are travelling around the roundabout until relatively late. If those on-site vehicles have managed to build up a reasonable amount of speed, the chances of a collision between one of these vehicles and one pulling out at the 'Give Way' line will be relatively high, particularly if the driver of one of the latter vehicles pulls out tentatively. Certainly, this 'sudden' appearance of vehicles travelling on the roundabout may be one of the main reasons for the number of left-turn conflicts observed at all four entrances at this site, the lack of appropriate sight distance being relevant for each entrance.

Excessive speeds may also be responsible for many of these left-turn conflicts. The mean values for the final approach speed at many of the entrances were in the region of 20mph with the large amount of variability, suggesting that some of the individual approach speeds may be in excess of 30mph. These high approach speeds so close to the 'Give Way' line imply that many drivers are committing themselves to entering the site, regardless of the status of other vehicles on the site. Certainly, many of them will be travelling too quickly to pull up in time should the need arise. A brief comparison of the fourth-segment approach speeds adopted by drivers involved in left-turn conflicts and those not involved in any conflicts was made. The fourth-segment speeds were used in place of final approach speeds as it was felt that many evasive action manoeuvres would be taking place in the final segment and would confound the issue. However, the results (see Section Q.2 in Appendix Q) showed that there was no significant difference between the speeds of the conflict-involved vehicles and the non-conflict-involved vehicles. This absence of an effect suggests that involvement in this form of conflict has little to do with approach speeds, although it should be pointed out that this analysis did not account for the presence of other vehicles. Indeed, it may be true that Cumming's (op. cit.) suggestion that some drivers cannot accurately relate sight distance and speed information may also be true at this junction.

Although correct site tracking was observed in the vast majority of cases (94.9%), the signalling behaviour of drivers at this site was particularly poor, with only 38.3% of drivers giving the correct signal when turning left. It may be remembered that signalling and site negotiation information could only be collected for vehicles turning left at this junction and this figure may not be representative of the signalling behaviour of all drivers. A higher proportion of drivers approaching from the West and North gave correct left signals (just under and just over half respectively), but under 30% of drivers approaching from the East and South gave the appropriate signal. Some of these cases may be explained away by drivers being unfamiliar with the junction and being unsure about their required exit road. However, it must be pointed out that adequate signposts are provided on each approach road, although it may be argued that, due to the speeds of approaching vehicles, they are too close to the junction. Some drivers on unfamiliar terrain and caught up the fairly dense traffic flow may have insufficient time to determine their exit. In spite of this, the extremely low percentage of correct left signals in general suggests that the problem is embedded in drivers' schemata of junction negotiation.

If any remedial measures are made to this roundabout, it is suggested that the first step should be to improve visibility across the junction by reducing the height of the central island and removing the trees and shrubs encircling it. It appears that only by enabling on-site traffic to be seen earlier by the driver approaching the site will the probable number of hastily-made decisions concerning pulling out onto the roundabout be reduced. In addition, it is suggested that the presence of speed humps on the entrance roads may help to reduce approach speeds, although the counter-arguments used in the previous section are also relevant here.

5.1.3 Descriptive Statistics for Site 3

As with Site 1, the expected morning and evening peaks for traffic flow were not accompanied by a mid-day peak at Site 3. Instead, the traffic flow remained more or less constant, only increasing slightly throughout the day. The situation at this junction is compounded by the close proximity of the bus and railway stations, and it is suggested that a high proportion of drivers observed at this site were visiting one of these places. The very similar number of vehicles observed during the morning and evening peaks (the evening period showing an increase of only 0.2% on the morning period) suggests that many of the drivers may have been commuters going to, and coming from, work using the train. The proximity of the bus station also accounts for the very high proportion of buses and coaches noted at this roundabout. The relatively small number of cars, although still by far the most common vehicle observed, was almost certainly affected by this large proportion of public service vehicles. The proportion of vehicles involved in conflicts was almost identical to that observed at the other roundabout, Site 2, with a non-conflict-to-conflict ratio of 13.3:1. In addition, the proportion of severe conflicts was identical.

Exactly half of the eight accidents at Site 3 for which details were available were of the left-turn classification, with the East and South entrances responsible for three each. The analysis of these type of traffic conflicts revealed that a third occurred at the North entrance, with the East and South entrances accounting for 52% together. When the amount of traffic using each of the entrances is considered, the East and West entrances account for proportionally more left-turn conflicts. It is interesting to note that, although the relationship between the number of accidents and number of all types of conflict is low for this site (see Table 4.13), the correlation between conflicts and traffic flow is extremely high ($r=0.953$, 90.8% variance accounted for). The mean approach speeds in the final sector were mainly in the region of 15 to 20mph and this may once again be a significant contributory factor to the incidence of this type of conflict. However, unlike Site 2, drivers approaching the junction have an excellent view of the traffic situation due to the only very slightly raised centre island and small size of the whole roundabout. The small size of the roundabout also ensures that the speed of on-site vehicles is not as great as those observed at Site 2. In only exceptional circumstances will drivers be involved in a left-turn incident at this site be able to argue that they were unable to see approaching vehicles, or that these vehicles were travelling too quickly, and pure errors of judgement must be responsible for many of the accidents and conflicts.

Only two of the featured accidents at this roundabout were rear-end collisions, one occurring on the South entrance, whilst details of the other were unobtainable. This entrance was also responsible for half of the twelve rear-end conflicts at this site, with the North entrance claiming all bar one of the remaining conflicts. However, it should be remembered that these two entrances accounted for exactly three-quarters of all vehicles observed to pass through the junction. Despite this, these two entrances claimed the highest percentage of close-following with 26.8% of vehicles travelling from the North and 31.9% from the South having a gap time of less than three seconds. Although this factor must surely be implicated in these conflicts, it should be noted that, in general, close-following was less prevalent at Site 3 than any of the other junctions studied.

Unlike the situation at the Site 2 roundabout, a high proportion of drivers were observed to display the appropriate indication, with a range of 79.1% for the East entrance to 90.0% for the North. This was particularly encouraging for the left-turning vehicles, suggesting that the very low success rate at Site 2 is may be specific to that junction, rather than a widely-demonstrated phenomenon. Conversely, junction negotiation at this site was the worst of all the junctions studied, with less than 80% (78.2) of drivers correctly negotiating the roundabout, compared to at least 94% recorded for all other sites. This is mainly due to the high proportion of drivers who 'straight-line' roundabouts such as this one, taking little account of the (unmarked) lane divisions on the roundabout. However, it is not suggested here that this practice is inherently dangerous, as the smaller traffic flow at this type of site mean that many straight-lining drivers do so without the presence of any on-site vehicles and therefore do not run the risk of a collision. It could be that these same drivers would adopt a more cautious approach if other vehicles were present.

Such straight-lining may not be a problem in itself, but it tends to be accompanied by faster site negotiation times, indicating that these drivers do not slow down significantly for the purpose of junction negotiation. Indeed, a brief comparison (see Section Q.3 of Appendix Q) of the final segment approach speeds for good and poor site negotiators revealed a significant difference between them, although the level of predictive association between the two variables was very low. For the vast majority of the time, drivers are able to do this without any problems but it is argued that they are putting themselves at greater risk should other vehicles be present. One of the ways in which highway engineers attempt to counteract this straight-lining is to increase the size of the centre island, ensuring deflection in the paths of approaching drivers. Lalani (1975) suggests that adequate deflection should be a standard feature of the design of all roundabouts. It is notable that, whilst only 66.9% of inside-lane drivers correctly negotiated the junction when travelling straight across, the equivalent figure for outside-lane approachers performing the same manoeuvre was 91.8%. The greater deflection these latter drivers must undertake leaves them with virtually no option but to take more care over junction negotiation.

Many of the possible reasons for the appearance of the types of behaviour observed at this site, particularly those resulting in left-turn and rear-end conflicts, were noted in the previous discussion of Site 2 and are equally relevant in this situation. The problem of excessive approach speeds may again be reduced by the introduction of speed-humps on entrance roads and an increase in the size of the centre island may be able to improve drivers' junction tracking behaviours. However, it is difficult to suggest any engineering countermeasures that could be made to reduce the amount of left-turn incidents as the sight distance at the junction is as extensive as possible and there being no other obvious obstructions to vision in the road furniture. These incidents must once again result from driver errors, for which it is unlikely that structural remedial measures could be made.

5.1.4 Descriptive Statistics for Site 4

The most notable aspect of the distribution of vehicles over the five time periods at this site was the quite considerable evening peak, accounting for many more vehicles than the morning peak. This is probably largely due to the fact that the progress of vehicles travelling through the site from North to South was not monitored, and so the number of vehicles using this route was not recorded. This route takes vehicles into the town of Bletchley, and it is probable that many drivers who work in the town would be using that route during the morning peak period. The high number of vehicles travelling in the opposite direction during the evening peak implies that many of these vehicles are driven by commuters.

The large proportion of light and heavy goods vehicles is explained by the presence of a large industrial estate to the North-East of the junction, accessed via the East exit. Relatively fewer conflicts were noted at this site, at which a non-conflict-to-conflict ratio of 16.4:1 was recorded. However, the proportion of severe conflicts was identical to that measured at other sites.

The major single type of accidents (35%) at Site 4 resulted from the merging manoeuvre executed by drivers travelling North along the V4 and turning right into the V6. Surprisingly, not a single instance of a traffic conflict of this nature was observed during the periods filmed. This must surely cast doubt upon the relationship between accidents and conflicts and it may be that Cooper (1973) is correct in stating that the two result from entirely different circumstances rather than the former being a more exaggerated example of the latter. The second most common accident-type resulted from drivers turning from the V6 to travel North along the V4 but failing to use the appropriate slip-road, thus necessitating crossing the lane on the V4 containing traffic travelling South. Cross-traffic conflicts were noted for six vehicles, every one of those that attempted this manoeuvre. This failure to observe the correct filtering procedure may have been due, at least partly, to inadequate signposting.

By far the most common form of conflict noted at this junction was the left-turn variety, particularly prevalent for vehicles turning from the V6 to travel South along the V4, accounting for 55.9% of these conflicts. This contrasts with the solitary case of an accident resulting from such manoeuvre recorded during the period of study. The relatively high speeds of vehicles travelling South along the V4 (ie. those not joining or leaving the V6) must be a major contributory factor to these conflicts, the traffic flow making it very difficult for drivers wishing to execute this manoeuvre to pull out onto the junction and reach a safe speed before a South-travelling vehicle arrives at the junction and a potential conflict place. Six of the fifty-three conflicts at Site 4 were of the rear-end shunt type, happening to vehicles queuing along the V6, waiting to turn left into the V4. Three such accidents were recorded at this junction, and, as the queues tended to be very slow-moving, may have been due to inattention in the drivers of the preceding vehicles. Indeed, 43.8% of drivers using this approach adopted a following time gap of under three seconds, although this figure will have been boosted by the smaller gaps noted in the slower-moving queues.

The only important category of conflict or accident at this site not yet noted concerns the relatively large proportion of rear-end type conflicts recorded in vehicles queuing to enter the V6, having travelled North along the V4. Again, this was generally a long, slow-moving queue, and some of the conflicts may also have been due to temporary lapses in attention. However, these situations would not have required vastly greater lapses in attention to result in an actual collision. Indeed, two such collisions were recorded during the accident period covered by this study.

So far, no mention has been made of vehicles using other paths through the junction. Those vehicles using the slip-road to travel North along the V4, having approached from the V6, were involved in five conflicts, three of which were of the cross-traffic variety as they crossed the Southbound carriageway of the V4 - the other two were rear-end conflicts whilst queuing to enter the junction. Both of these cross-traffic conflicts involved drivers who had pulled out onto the junction but been unable to reach the far side due to on-coming traffic moving at high speed. Yet again, the speed and density of traffic travelling straight through this junction often made it very difficult for drivers to enter the site without exposing themselves to some degree of risk. Vehicles taking this route were also studied in greater detail as they crossed the Eastbound carriageway of the V6 to use the slip-road. Two cross-traffic conflicts were noted whilst performing this manoeuvre, with a further rear-end conflict recorded as a driver queued to cross this road. No actual accidents of either category were noted.

Three of the four drivers involved in conflicts whilst using the slip-road in the opposite direction (to travel along the V6, having approached the junction South along the V4) encountered the same circumstances, even though somewhat less severe. Whilst waiting at the 'Give Way' line to enter the V6, these drivers had to find a gap in the almost constant flow of traffic entering from the V4 (approaching from the South) and already having built up quite a speed.

Junction negotiation for vehicles at Site 4 was excellent, with at least 93% of vehicles performing any one manoeuvre doing so correctly. It should be noted, however, that the design of the junction meant that such incorrect tracking manoeuvres were more difficult to make than at most other junctions, all entrance roads having only one lane, for example. Right turns were generally indicated with a great deal of accuracy (87.6%) but only just over half of left turns were accompanied by the appropriate signal. This is perhaps not so surprising as the left signals other junctions, particularly at Site 2, have been similarly poor, suggesting that many drivers do not feel that it is important to indicate an intention to execute a left turn. Right turns have been generally well-signalled, and it is suggested that the more complex manoeuvre involved in turning right ensures that drivers focus more upon the whole task of turning than is necessary when performing the relatively straightforward left turn.

It is probable that the speeds of vehicles travelling straight through the junction is a major contributory factor to many of the conflicts, and accidents, recorded at this junction. Some vehicles joining the main (V4) road at every intersection encountered difficulties, and it appears sensible that attempts to reduce the speeds of these vehicles were made. The channelisation of traffic at busy junctions by using slip-roads has been shown to reduce accidents in some cases (eg. Shaw, 1966, cited by OECD, 1976), particularly those resulting from left-turning manoeuvres. A 1976 report by the Organisation for Economic Organisation and Development (OECD) suggests that this is due to the reduction in the number of possible conflict points brought about by the separation of competing traffic streams. The number of accidents at this junction suggest that the design was not perfect and, as previously noted in Section 3.1.4, this junction has been changed into a roundabout since the completion of the observation study. Research (eg. that conducted by the Transport and Road Research Laboratory in 1975) has shown that the introduction of offside priority (ie. giving way to traffic coming from the right) roundabouts to seventy-eight British sites reduced the number and severity of accidents at those sites. Certainly, the alterations to the priorities through this junction should reduce the incident rate simply by making the junction more user-friendly. However, it is likely that this will be accompanied by a reduction in traffic flow rates as the main V4 road carried the majority of traffic through the junction.

5.1.5 Evaluation of Individual Site Analyses

The diagnoses of individual junctions in this section provided some interesting discussion points. In some cases (eg. for left-turn conflicts at Site 1), there was shown to be a high level of correspondence between the conflicts observed in this study and the accident record of that site. However, this was not true in all situations. The high number of major to minor road cross-traffic accidents at Site 4 was not reflected by a single example of such a conflict during the period of observation.

Several contributory factors were suggested to account for many of the incidents. For example, it was argued that limited sight distances played a part in many of the accidents and conflicts at Sites 1 and 2. Excessive approach speeds were also deemed to be a common problem for all junctions studied, and short following times were also implicated in some cases. Although it was considered that the poor standard of direction indications would, in itself, not be a major accident-causing factor, it was still interesting to note the high incidence of incorrect or, particularly for left turns, absent signals.

Remedial measures were suggested in some cases, the most common being the introduction of speed-reduction devices to approach roads. Removing the obscuring vegetation on the centre island of Site 2 was suggested, and it was advised that an increase in the size of the centre island at Site 3 may help to reduce approach speeds and straight-lining behaviour. Other means of reducing undesirable driving practices at junctions have often been suggested. For example, Millar and Generowicz (1980) found that the presence of police surveillance at junctions reduced the incidence of unsafe behaviours, and it may be remembered from Section 1.3.2 that Riedel, Rothengatter and de Bruin (1986, cited by Rothengatter, 1987) found that the perceived level of police surveillance had a positive effect on the effectiveness of that surveillance. However, the problems associated with this form of treatment have been discussed in that previous section and it remains the premise of this research that the most effective method of reducing undesirable driving practices is via educational means.

The next section of the discussion will focus upon the inferential statistical techniques carried out on the observational data.

5.2: DISCUSSION OF INFERENTIAL ANALYSES

5.2.0 Overview of Discussion of Inferential Analyses

Prior to discussing the issues that emerged from the inferential analyses, it should be remembered that they were accompanied by a note of caution (outlined in Section 4.4.0). The main concern was that, due to the relative low numbers of certain types of behaviours at each junction, the data for all four sites were combined for the purposes of these analyses. It was argued that, by doing this, any interesting factors connected to one site, or even one part of one site, would be obscured by the whole.

It emerged from the previous section that each site had highly idiosyncratic features in terms of observed behaviours, and these differences were also true intra-site as well as inter-site. Certainly, the situations encountered by drivers approaching a site from the same direction but in different lanes are quite different in many cases, and it is argued that each entrance lane should be treated as, effectively, a distinct junction with its' own unique features, driving styles and problems. Therefore, it is recommended that these analyses be treated as exploratory in nature, highlighting areas for future study and providing material for the second part of this research.

5.2.1 Analyses of Vehicle Approach Speeds

5.2.1.1 Approach Speeds of Different Classes of Road Users

The first series of analyses, looking at unimpeded (ie. without the presence of a queue) approach speeds, used the analysis of variance technique to test for any differences between vehicles classes. Unfortunately, in many cases, there were simply not enough examples of many vehicle types. This was particularly true at Site 1 where only cars and light goods vehicles could be included, and the Site 4 tests only included one additional vehicle category. It is interesting to note that the analyses combining data from all four sites were each significant at the 5% level, whilst only two out of the eight individual site analyses showed this degree of significance. However, there are several problems with the combination of data in these cases because, as already noted, the analyses of some sites contained a small number of vehicle classes, and therefore the tests for all sites contained mainly cases from Sites 2 and 3 for the majority of vehicle classes.

If there were any actual differences in the approach speeds of different vehicle types, one might expect this to be revealed at each junction studied. The fact that this has not been shown indicates that the differences observed may be an interaction between driver characteristics, vehicle and junction type. Unfortunately, this form of analysis would require additional information to that collected and is therefore beyond the scope of this study. The practical advantages of knowing which, if any, types of vehicles are driven more quickly on the approaches to junctions are unclear as all drivers will be exposed to any countermeasures taken to overcome the speeding problem. This is especially true of the introduction of engineering solutions, such as speed ramps, as drivers of all types of vehicles must take the same routes through junctions. It has been noted, however, that motorcyclists and moped riders had an overall tendency to accelerate onto the junctions, suggesting that, if publicity or educational messages are directed at any group of road users, it should be these. However, it should be pointed out that the numbers of such users was relatively small, and more data would need to be collected before it could be ascertained with any degree of certainty whether this group merits special attention.

These analyses were not especially successful in their ability to discriminate between road users of different classes of vehicles and, due to the overall low levels of predictive association connected with these analyses, it may be that any effects demonstrated may be purely 'statistical', rather than actual, phenomena. It is argued that, in addition to merely identifying which road users approach junctions more quickly, it would be far more useful to discover the reasons why such drivers adopt high approach speeds.

5.2.1.2 Approach Speeds Used as Dependent Variables

The multiple regression analyses in which four variables were used to predict various approach speeds at the four junctions, together and separately, produced generally poor solutions. Only the analyses using the speed in the final approach segment produced reasonable overall solutions, with the density of traffic being the only predictor variable that reached the criterion level regularly, indicating an inverse relationship between this approach speed and the number of other vehicles present at the junction. It should not be too surprising to learn that drivers tend to be more cautious when approaching a crowded junction than a relatively empty one. Indeed, this supports the finding of Roer (1968, cited by Wilde, 1980) who discovered that drivers make relatively more effective efforts to avoid accidents when approaching high-traffic-volume junctions than when approaching low-volume examples. The other independent variable that achieved the criterion level of prediction on more than a single occasion was that recording the gap time between the study vehicle and the preceding vehicle. However, the analysis using the first approach speed as the dependent variable at Site 4 showed an inverse relationship between following time and speed, whilst the analysis using the final approach at Site 1 revealed a positive relationship between the variables. Once again, this demonstrates the widely different conditions at each road location and provides more evidence against the combining of data from different sites.

One of the major problems with these analyses is that, by the very nature of the study, only external factors could be included in the equations. Approach speeds are far more likely to be influenced by individual characteristics of the drivers and their reactions to the immediate environment in which they find themselves. For example, age and sex factors may be implicated in speed selection. Michiels and Schneider (1984) found that young male drivers were more likely to commit excessive speed traffic violations than their older counterparts. In addition, Ellinghaus and Schlag (1984) discovered that speeding was the most frequent cause of accidents in the 18-24 year old age group, older drivers having fewer speed-related accidents. Unfortunately, the age and sex of drivers of vehicles featured in the observation study could not be recorded, and only variables external to the vehicle could be included in the analyses.

5.2.2 Analyses Using Signalling Behaviour as Dependent Variables

The descriptive statistics had highlighted a problem with signalling behaviour and it was hoped that this series of analyses would be able to identify factors that may be associated with this. Separate analyses were carried out for each individual site in addition to one using data from all sites. The overall solutions proved to be relatively poor predictors of correct/incorrect signalling behaviour and no individual variables emerged as consistently good predictors. Indeed, the independent variables that were shown to be good predictors were different for each analysis, and this only serves to reinforce the argument that the situation at each junction is very different and attempts to generalise causal relationships between factors and inappropriate driving behaviours may be a fundamentally flawed approach. For example, the variable measuring traffic density was found to be a reasonably good predictor of signalling behaviour at three sites (1, 2 and 3), but for two of the junctions, a higher traffic density was found to predict correct signalling, whilst at the other site (3), the opposite was true.

Other individual variables were found to be reasonably good predictors of signalling behaviour, particularly the final approach speed (for the all-sites and Site 3 analyses) and the total amount of time the vehicle spent negotiating the junction (all sites and 2, 3 and 4 individually), but the small amount of variance accounted for by the equations suggests that little attention should be paid to this. Perhaps one of the problems associated with the tests included here was the fact that all types of signalling behaviour (whether left, right or none at all) were included in the same analyses, and it is possible that there are, for example, different factors associated with incorrect left signalling and with incorrect right signalling. As noted in the previous section in relation to selection of approach speeds, the use of direction indicators is governed by the driver, and it is more likely that their use (or not) will be a function of driver variables rather than external, environmental factors. These environmental factors may play some part, but it is argued that a thorough investigation of signalling behaviours must include these internal, driver variables in addition to the environmental ones recorded in this study.

5.2.3 Analyses Using Site Negotiation as Dependent Variables

Once more, this series of analyses were performed in response to a problem highlighted earlier in this study and aimed to discover which, if any, factors were associated with incorrect junction tracking. Again, individual and collective site analyses were attempted, but insufficient data meant that two of the site-specific tests could not be used. In addition, the lack of data for any vehicles at Site 2 other than those turning left meant that only the tracking of these left-turning vehicles could be included in the relevant analysis. This produced a rather confusing situation regarding the combined-sites analysis as the vast majority of the cases included came from the Site 3 data set.

It is surprising, therefore, to discover that the solutions produced by these two discriminant function analyses were quite different, the overall solution being able to account for more variance than the Site 3 solution (23.7% and 14.7% respectively). The individual variables contributing to the solutions were found to be reasonably similar, but it is interesting to note that the direction of the main independent variables differed between the two solutions. For example, the final approach speed featured as the best discriminating variable in both solutions, but whilst a high speed was associated with good tracking for the overall solution, slower speeds relating to correct tracking at Site 3. This serves to illustrate the point previously outlined that combination of data from several sites only serves to confuse the issue. In this case, the addition of under a hundred cases from Site 2 changed the outcome of the Site 3 analysis quite considerably. In light of this, it is recommended that any future attempts to assess contributory factors to such phenomenon as poor site tracking (or signalling) should look at each site, and possibly even each arm of that junction, individually. As stated in the previous two sections, it is also considered vital that variables relating to the drivers are included in such investigations.

5.2.4 Analyses Using Traffic Conflicts as Dependent Variables

As previously noted in Section 4.6.2, Grayson and Hakkert (1987) suggested that the way forward for traffic conflict research was to make these conflicts the dependent variables in subsequent analyses in order to determine which variables are able to predict conflict involvement. The analyses described in section 4.6.2 attempted to do just this using a variety of environmental variables as predictors. The two-function solution was found to account for a large portion of the total variance and to be able to correctly classify a highly significant number of cases. The first function was found to be discriminating between the two forms of conflict included, left-turn and rear-end, the second between conflict-involved vehicles and non-conflict-involved vehicles.

The independent variable recording the presence or absence of a queue of vehicles waiting at the 'Give Way' line or equivalent (ie. a queue on a main road waiting to turn into a side road) was found to be the best predictor of conflict type. Drivers faced with a queue were more likely to be involved in a rear-end type conflict and less likely to be involved in a left-turn type conflict. This is not surprising given that a queue of traffic is an essential prerequisite for the former category of conflict (otherwise the driver would have no vehicle to almost run into the back of). The absence of such a queue for the passage of merging vehicles suggests that the drivers of such vehicles, having a more uninterrupted flow, entered the junctions with less attention paid to other vehicles on the site. Indeed, the individual analysis of left-turn-conflict-involved vehicles and those vehicles not involved in any conflicts revealed that drivers stopping at the 'Give Way' line were less likely to be involved in such a conflict than those who did not. This implies that the more care the driver takes in observing the status of other vehicles on the junction when approaching, the less likely they are to become involved in a left-turn conflict, as common sense dictates they should be. Similarly, the importance of some of the other predictor variables in contributing to the overall solutions should not be surprising. For example, the presence of (at least) one other vehicle on the junction as the study vehicle approached should be highly correlated with the presence of an approach queue and an increased risk when pulling out at the 'Give Way' line. Additionally, the single-factor solution using rear-end type conflicts versus no conflicts as the dependent variable revealed that the variable measuring following distance was one of the two strongest predictors of involvement in this form of conflict.

On the surface, it appears that these analyses were far more satisfactory than those outlined in the preceding sections. However, it should be remembered that, due to a shortage of cases at some sites, individual junction-specific analyses could not be performed. Given that the individual analyses differed from the collective analyses in these previous sections, it follows that the same would probably have been true of these conflict tests. The only remedy to this problem would be to perform more extensive studies at each of the sites, ensuring that enough conflicts to perform reliable statistical analyses were recorded at each junction. It is argued, however, that these studies are sufficient to provide pointers for further research, particularly the proposed second part of the current project.

The use of the traffic conflicts technique in this context is still debatable, and issues relating to this will be covered in a subsequent section (5.4.5). In addition, the individual conflict types, the left-turn and rear-end, will undergo further scrutiny in the section following the summary.

5.2.5 Overall Evaluation of Inferential Analyses

On the whole, the inferential analyses reported for the first study were unsatisfactory and unable to provide much material for the second study. One of the main problems concerned the grouping of data from several sites into single analyses, and it was felt, particularly following on from the descriptive statistics described earlier, that sites should be treated on a purely individual basis. The junctions used in this observation study were all of quite different formats, and the conclusion that each site requires an entirely separate treatment is probably a reflection of this divergence. It was felt that the combination of data was likely to mask potential observable effects specific to individual sites, or parts of sites, and therefore the analyses were unlikely to produce a consistent result across junctions.

However, some useful information that could be utilised in the second study were found, particularly in relation to traffic conflicts, by far the most robust series of analyses reported in this section.

5.3: DISCUSSION OF THE MAIN CATEGORIES OF INCIDENT

5.3.0 Overview

Three major categories of accidents were noted during the initial assessment of the accidents at the four junctions adopted for this study, and the subsequent observation of these sites revealed that there were many instances of near-misses of an apparently similar nature to these accidents. In some cases (eg. left-turn conflicts at Site 1), the correspondence between accidents and conflicts was good, in other cases (eg. cross-traffic incidents at Site 4) there appeared to no such correspondence.

On the basis of his own observation work, Cooper (1973) has argued that the circumstances leading up to accidents and conflicts are not necessarily the same, and that it is a mistake to use the terms interchangeably. However, it is argued that at least some aspects of the manoeuvres leading up to these two types of incident must share some common elements. For example, it makes intuitive sense to assume that a driver who close-follows another vehicle when approaching a junction stands a greater risk of involvement in both a traffic conflict and an actual accident than if the selected gap time was greater. Therefore the term 'incident' is used in this section to refer to both conflicts and accidents. However, it should be noted that this does not necessarily imply that it is assumed that the former phenomenon is a more 'intense' version of the latter.

5.3.1 Rear-End-Shunt-Type Incidents

The fact that approximately a third of vehicle studied were found to be following the preceding vehicle with gaps of less than three seconds suggests that, in terms of the extent of the 'problem', the situation on the approach to junctions has parallels to motorway close-following as reported by Postans and Wilson (1983, see Section 2.1.1). It should be noted, however, that the proportions reported in this study did not account for lone vehicles travelling through the junctions. In other words, the drivers of many vehicles could not have followed another vehicle closely, due to the absence of other such vehicles. It is therefore likely that the true figure for close following (in which the driver had some degree of choice as to the following distance adopted) will be much higher.

Additionally, following times and the presence of a queue were shown to be good predictors of involvement in this kind of traffic conflict. It makes intuitive sense that drivers who leave a small gap between their vehicles and the vehicle in front are more likely to become involved in an incident when the driver of the leading vehicle reduces speed on the approach to a junction. The important issue here is why some drivers select following times that are clearly going to cause problems should the 'unexpected' happen.

It seems likely that this form of conflict is one of those, referred to by Wilde (1980), which arises:

"...when different participants in a situation act accordingly to discrepant formal and informal rules pertaining to that situation. This is because a driver's ability to predict the behaviour of another driver correctly is greatly reduced if the other driver acts under a different norm system." (Wilde, 1980, p. 440).

This kind of argument owes much to those covered towards the end of Chapter 1 in the discussions of driving schema and surely provides directions for the next study.

5.3.2 Left-Turn-Type Incidents

The influence of factors such as sight distance have already been discussed in relation to this form of incident (see Section 5.1.1), but it is argued that variables more directly associated with the drivers themselves are of more interest than such environmental factors. For instance, a driver wishing to join the main flow of traffic on a junction with a limited sight distance must take this limit to vision into account when choosing the moment to enter the junction. Clearly, one of the most important variables in this situation is the driver's gap acceptance criterion, and it would seem likely drivers have widely differing gap acceptance times.

For example, there is evidence to suggest that drivers base their decision to pull out on gaps measured by time rather than by distance (Cooper, Smith and Brodie, 1976). Individual differences may also play a part and a study by McDowell, Wennell, Storr and Darzentas (1983, see Section 2.1.2) looked at the gap acceptance times of drivers at a simulated priority-controlled T-junction. In this study, female drivers were found to accept significantly larger gaps than male drivers for two of the manoeuvres studied, which the authors interpreted as implying that female drivers were more cautious than their male counterparts. It is also interesting to note that an earlier study (Darzentas, McDowell and Cooper, 1980) had found that younger drivers of both sexes accepted shorter gaps than older drivers, but were shown to be more consistent.

In addition to these differences in gap acceptance times, researchers have noted other individual differences at junctions that are relevant here. For instance, a study by Leff and Gunn (1973) looked at the interactions of male and female drivers at roundabouts and discovered that the male drivers generally took precedence over female drivers. The researchers offered several possible explanations for this phenomenon, such as differences in car size or a general tendency for women to yield to men, but perhaps the most plausible explanation was the assertion that this behaviour was a function of males' general higher level of aggression, particularly in the driving situation. Another study that examined more social aspects of driver interactions was performed by Rubin, Steinberg and Gerrein (1974) who looked specifically at determination of the right of way at junctions. Their subjects were found to be:

"...more effectively deterred from assuming the right of way when the 'other driver' systematically avoided rather than embellished eye contact, and was female rather than male." (Rubin, Steinberg and Gerrein, 1974, p. 1271).

The researchers also performed a questionnaire study and were able to determine that this failure to establish eye contact with another driver was seen as indicative of having little control over that person's behaviour. In addition, drivers of both sexes viewed female drivers as more unpredictable, less rational and less knowledgeable than male drivers.

It has previously been noted (Section 2.1.2) that the mere presence of other drivers has also been shown to affect the risks that drivers are prepared to take when entering a junction. Ebbesen and Haney (1973) discovered that drivers who had to wait in a queue of traffic before entering the junction took greater risks than those who had not been required to wait. However, the presence of a vehicle behind or to the side of a driver did not have any effect on the risk taken. The data collected for the current study meant that these findings could be directly tested. The level of risk was determined by the variable PULLOUT, measuring the time lapse between the study vehicle pulling out and the arrival of another vehicle at the potential point of impact where the paths of the two vehicles crossed. It was found (see Section Q.4 in Appendix Q) that drivers who had to queue actually accepted a significantly greater mean clearance time than those who did not queue, although there was found to be virtually no predictive association between these variables.

The length of time a driver waited at the line was also found (see Section Q.5 in Appendix Q) to have a significant affect upon acceptance times, the longer the driver waited, the more caution they displayed. Additionally, drivers accompanied by another vehicle to one side were also found (see Section Q.6 in Appendix Q) to be significantly more cautious than those without, although again the level of predictive association was low. These tests contradict the findings of Ebbesen and Haney and suggests that the immediate presence of other vehicles, and being made to wait before entering a junction, serves to make drivers more cautious than otherwise. It should be noted, however, that the times measured by PULLOUT are not the most reliable guides to drivers' gap acceptance times.

It should be evident that there are many factors which may affect the decisions made by drivers wishing to pull out into a stream of traffic, and that these include both environmental and driver variables. It seems logical, therefore, to ensure that one of the primary aims of the second study is to determine some of the factors that may be associated with this phenomenon.

5.3.3 Cross-Traffic-Type Incidents

The low number of cross-traffic incidents (14 - mainly at Site 4) recorded meant that inferential analyses could not be performed using cross-traffic conflicts as dependent variables. It should be clear that, whilst they may share some similarities (ie. whereby the driver must judge whether the gap in the traffic stream is sufficient to allow their vehicle through and to enable them to join their chosen traffic stream safely), left-turn and cross-traffic incidents result from two distinct categories of manoeuvres. The former involves merging with the traffic flow after pulling out, the latter involving actually crossing a stream of traffic and then merging with the traffic flow. Despite this, Darzentas, Holms and McDowell (1980) discovered no significant differences between drivers' acceptance times for these two forms of manoeuvre, although only the range of four to nine seconds was covered and the authors acknowledged the possibility that differences may exist for gap acceptance times below four seconds.

As with the other forms of conflicts discussed, it is unlikely that the type of external variables recorded in this study would be able to predict involvement in cross-traffic conflicts with any degree of certainty. Of more interest are individual gap acceptance times and the factors and circumstances that contribute towards drivers accepting shorter gap times than usual.

5.4: ASSESSMENT OF METHODOLOGY FOR STUDY 1

5.4.1 Site Selection Criteria

The assessment of any methodology should attempt to determine the extent to which the achieved sample represents the population. In this case, the sample was dependent upon the junctions selected for observation and the representativeness of these junctions must be discussed. The sites were selected on the basis of a relatively high accident record over a short period of time simply because, having no other information to go on, analysis of these sites would be more likely to reveal more inappropriate driving practices than analysis of a random sample of sites. One potential consequence of selecting sites on the basis of poor accident records is the regression-to-the-mean effect outlined in Chapter 2 (Section 2.1.2.2). However, this is only really a problem when 'before' and 'after' studies, in which the changes in accident patterns over time are noted, are being carried out. In this case, the main purpose of this first study was to produce a catalogue of the poor driving practices at junctions rather than an absolute measure of accident numbers and types. Although it would obviously have been preferable to look at a wider range of junctions, it is argued that, given the restraints on resources, the number and type of sites used provided data on a reasonable cross-section of junctions in the area.

One of the main problems with the junctions selected was the lack of information that could be collected about certain aspects of the passage of vehicles through Site 2, most notably the absence of information for any vehicles other than left-turning vehicles beyond a certain point. Unfortunately, this will always be a problem when recording information about very large junctions such as this one, and it is felt that such sites should not be excluded from study on this basis as much valuable information was still gathered about this junction. However, it is suggested that any future research projects of this nature could, rather than neglecting to study such large sites, adopt a slightly different method of recording information. Only one video camera was used at any one time during this study, and it would probably be more effective if several cameras, focused on different parts of the junction, were used. However, this requires an increase in the number of personnel, in addition to video equipment, and therefore beyond the means of this study.

5.4.2 Use of the Observation Technique

Although alternative techniques of recording information about driving practices at junction were considered (see Section 2.3), it is felt that a brief assessment of that technique is warranted. It must be remembered that this study required a realistic representation of the types of behaviours on display every day at British junctions, and it is argued that other methods of recording information could not have achieved this. For example, it is unlikely that respondents would admit to such poor rates of correct signalling behaviours if asked to report on their own driving behaviour via a questionnaire. Similarly, many drivers may be unaware of some deficiencies in their driving practices, and therefore be unable to report them. Test-track and in-car studies would have been unlikely to provide an true perspective on these behaviours as drivers would have been more likely to be on their 'best' behaviour, suppressing undesirable practices such as straight-lining roundabouts. It is also unlikely that, using either of these techniques, such a large sample could have been derived.

In addition to the sometimes restricted views (dealt with in the previous section), perhaps the only real criticism of the observation technique as used in this study concerns the position of the video camera in relation to the traffic. It is possible that many drivers noted the presence of the camera and, aware that they were being observed, adjusted their driving style accordingly. Although the literature appears to contain no evidence to support this hypothesis, an in-car study by Harvey, Jenkins and Sumner (1975) did show that the presence of an experimenter in the vehicle probably reduced the number and severity of errors committed by drivers. Such effects may have been in operation in this study, but until research has shown whether there is a difference in driving practices in the presence of visible and concealed video cameras, it is felt that there is no reason to recommend alternative techniques at this time.

5.4.3 Sampling Adequacy

If inferences about general behaviour at the junctions studied are to be made, it is clear that the representativeness of the data must be assessed. A major problem with the sampling strategy employed was that, because all information for each site was recorded on a single day, details for only one weather and road condition could be recorded. Given the relatively high numbers of accidents in which vehicles skidded on poor road surfaces, it would seem logical that the recording taken should represent these, as well as normal, driving conditions. Unfortunately, the limited amount of time in which the observation study had to be completed meant that it was not possible to prolong the recording to cover such conditions. Of course, a truly accurate representation would cover all possible road and weather conditions and, ideal as this would have been, the practical implications rendered this impossible. Similarly, it would have been preferable to record activity at the junctions at night as well as during the day although the limitations of the video equipment ensured that this was not possible.

However, it should be pointed out that there is evidence (Glauz and Migletz, 1980) to suggest that there are no consistent daily differences in conflict activity.

Although it is not possible to present the behaviours reported in this study as a definitive guide to the complete range of behaviours at the junctions in question, it is felt that they provide as accurate a picture as was possible under the circumstances. It is unclear how much daily variability there is in the types of behaviours recorded here, but it seems unlikely that there will be sufficient to cause concern. In any case, the main purpose of this study was to act in an exploratory sense aiming to provide basic descriptive information about the behaviours at the selected junctions, rather than providing absolute records of specific practices.

The number of cases analysed for each site should be subjected to some discussion. Although only half of the data recorded for Site 2 was used, it still provided more cases than any other site, and, given that each five minute segment was randomly selected from the whole ten minute segment, it can be argued that the analysis of the remaining half would have produced no useful additional information, other than the total number of vehicle passing through the site. A larger problem concerns the small number of vehicles observed at Site 1. The information recorded at this site is equally as likely to be representative of the entire range of behaviours at that site as at any of the other sites covered. However, the small number of examples of certain types of behaviours recorded meant that some analyses could not be carried out. Despite this, there was sufficient information to adequately describe behaviour at the site and to perform the majority of the tests.

5.4.4 Adequacy of Observation Variables

The majority of the variables used to plot the progress of vehicles through the junctions were used in the analyses reported in the previous chapter. Others, such as those recording weather and road surface conditions, were not used because such conditions remained constant for all filming periods.

One group of variables that was not able to provide a truly representative picture were those concerned with the positions and movements of other vehicles relative to the study vehicle. The situation at a junction as a vehicle approaches is highly dynamic, with many constantly changing variables possibly affecting the way in which the driver of that vehicle perceives and negotiates the junction. This is particularly true of the movements of other vehicles, and it is felt that the measures adopted in this study to cover this were relatively crude. Ideally, the movements of all other vehicles present during the passage of a single vehicle through the site would have been plotted. However, there are many other variables that it would have been useful to record concerning these other vehicles, such as the sex of the drivers and the amount of eye contact made (both outlined by previous research as potential variables affecting behaviour at junctions - see Section 5.3.1). The level and type of information that could have been recorded is considerable, and, for practical reasons, the line had to be drawn somewhere. The recording of the absolute movements of other vehicles would have required a great deal of additional input, and it is argued that the contribution such additional information would have been able to make was not sufficient to merit its' inclusion. However, if single-site analyses are to be carried out in any future projects, it is recommended that such matters are given due consideration.

The other important aspect of approach behaviour that could not be accurately recorded was braking activity, particularly the moment of onset. It is possible that, had such activity been accurately measured, it may have been possible to determine which aspects of the environment contributed to drivers' decisions to brake. However, such information could never determine any causal relationships, as many variables which could potentially affect the decision to commence braking will be internal to the driver and therefore unable to be recorded in an observation study such as this. However, it is likely that such analyses could have provided useful material for the second study. It was noted in Section 3.2 that the positions for the video camera selected were a compromise adopted to maximise the amount of useful information. Positions more distant from the junctions, such as would have been necessary to record braking activity comprehensively, had the disadvantage of not being able to provide enough details of activity at the 'Give Way' lines and on the junctions themselves. Given the importance of these variables, it is felt that the sacrifice of braking information was worth it and that the compromise was justified. However, as mentioned in the previous section, the use of additional video cameras would have solved this problem, but practical considerations made this impossible.

Finally, the use of the same database for all sites should be discussed. Although the situation on the approaches of the two roundabouts may be considered to be identical in terms of the types of variables in force, it is debatable that the same can be said of the other two junctions. At Sites 1 and 4, the process by which vehicles join the main stream of traffic is arguably the same, or very similar, to that at a roundabout. Both systems involve approaching a 'Give Way' (or in some cases, not studied here, 'Stop' lines), perhaps queuing to enter the junction, and finally, having decided when to enter the junction, merging with the stream of traffic. The same set of variables used for the study of the roundabouts were also found to be perfectly adequate in these circumstances. The only differences involved the situations in which vehicles were turning from a major road to a minor road by cutting across a stream of traffic. However, by assigning different meanings to the same variables for these cases, there was found to be no problems with adopting this system of fitting all the information onto one database.

5.4.5 Use of the Traffic Conflicts Technique

In addition to the descriptive analysis of the four junctions in this study, the Traffic Conflicts Technique was used in its' suggested (see Grayson and Hakkert, 1987) role as a diagnostic technique to highlight problem behaviours at these road locations. It was found that approximately 7% of all drivers were involved in conflicts at the junctions and the statistical tests using the two major conflict types carried out revealed surprisingly good solutions in terms of predicting conflict involvement. However, in the latter analyses, the variables that emerged as good predictors, such as the presence of a queue at the junction, appealed more to common sense and were, mainly due to the nature of the first study, unable to reveal much about any causal relationships implicated with near-miss incidents. For example, a queue of vehicles waiting at the 'Give Way' line may make drivers more prone to being involved in a rear-end shunt conflict, but such a queue will never actually *cause* an incident. It is suggested that the difference between involvement and non-involvement in such a conflict must lie, ultimately, with the driver and cannot be uncovered by an observation technique.

One of the major questions concerned with the traffic conflicts technique is the extent to which conflict counts represent accident patterns, an issue tackled in Section 2.2.2. Section 4.6.1 revealed that the relationship between observed conflicts and reported accidents (when traffic flow was accounted for) was highly positively correlated when data from all sites was combined, and also for Sites 1 and 2 individually. However, a strong relationship in the opposite direction (ie. the more the number of accidents reported, the lower the number of conflicts observed) was found for Site 3, and a very low negative effect for Site 4. This implies that each site has an idiosyncratic relationship between accidents and conflicts and that the general situation is more complicated than a straightforward correlation between the two variables. Indeed, it makes intuitive sense to think of an accident as a conflict for which the evasive action was taken too late or completely absent and that the two should be:

"...symptomatic of the same things that cause (or contribute to) accidents." (Glauz and Migletz, 1980, p. 29).

However, it may be remembered (from Section 2.2.1) that Cooper (1973) had suggested that accidents and conflicts may have fundamentally different antecedent factors and, if this were the case, it would be surprising if a consistent relationship between the two variables were demonstrated.

In a later paper, Cooper (1977) argues that it could be that collisions occur in circumstances for which there is an absence of stimuli inducing evasive action available to the driver. Quite what these circumstances may be remains obscure, as do the types of stimuli which may induce evasive action to be taken. It is possible that these circumstances may be a function of environmental factors associated with a particular site (such as sight distance) and that the nature of the relationship between accidents and conflicts is dependent upon such, as yet, uncharted elements. Certainly, the partial correlations reported in Section 4.6.1 appear to support Cooper's notion in theory and it is argued that a more thorough investigation of a wider range of junctions, including detailed analysis of possible contributory environmental effects, is needed before any relationship between traffic conflicts and accidents, if indeed there is a consistent one, can be established.

One of the major problems may be the fact that the conflict rates are, by necessity, always compared to reported, rather than actual, accident rates and it could be that conflicts are always highly correlated with these actual accident rates. Unfortunately, whilst this complete information remains unavailable, the arguments (eg. Hauer and Garder, 1986 - outlined in Section 2.2.2) that suggest that, due to the wild fluctuations in annual reported accident rates at any location, the investigation of any such relationship is fundamentally flawed, must be supported.

However, the fact that a relationship between conflicts and accidents has not been demonstrated does not imply that the traffic conflicts technique is not useful. The main purpose of its inclusion in the present study was to act as a diagnostic tool to identify factors associated with obviously hazardous manoeuvres (given that one or more drivers felt that some evasive action was necessary). As such, it is argued that it was able to provide some useful information concerning the quantity and type of undesirable driving practices at these junctions. In some cases, these behaviours appeared to bear similarities to accidents reported at the same locations, in other cases, this was not demonstrated. However, the fluctuations of accident quantities may also be accompanied by fluctuations in accident type, and it may be that conflicts pertaining to certain types of accidents were not observed because the nature of accidents at that location had changed since the relevant records were taken. Without performing a longitudinal study, with preand post-conflict-measurement accident records to compare, it is impossible to determine the existence of such changes.

Another factor which should be given some consideration is the adequacy of the specific traffic conflicts technique methodology used in this study. One of the key points of contention has been the training of observers to record conflicts in a consistent fashion. Researchers such as Kryusse and Wijhuizen (1988) have found that untrained observers were able to record conflicts with as much consistency as trained observers. Despite such findings, it was felt necessary to apply some form of checking procedure. This highlights the advantages of using video equipment to initially record the conflicts as it enables reliability testing to be performed on the very data, or samples of that data, to be used in the analyses. The high levels of inter and intra-rater reliability in this study (see Section 3.5.1) vindicate the use of this technique. In fact, from his own study comparing subjective with objective methods of recording traffic conflicts, Shinar concluded that:

"...people have an internal concept of what constitutes a conflict or near accident and are consistent in their evaluation of vehicle movements relative to that concept." (Shinar, 1984, p. 156).

It should also be pointed out that the use of on-site observers recording the conflicts as they happened would not have been in a position to collect the quality and quantity of additional data (such as approach speeds) that was used in the analyses relating to traffic conflicts. If used in a purely diagnostic sense, it seems logical that these additional variables should be recorded, especially as it requires no additional effort at the time of recording.

In spite of the many conceptual difficulties of the traffic conflicts technique, particularly in its' relationship with accidents, it is felt that the technique, when used in the diagnostic sense, is able to provide much useful information about driving practices at a particular location. It is, however, unable to provide information concerning the internal, driver-centred factors connected with accidents at junctions and it is suggested that the second study should focus upon this issue. Prior to the introduction to this second study, the following section summarizes the discussion of the first study, and the contribution the information gained can make to this follow-up piece of research.

5.5: SUMMARY OF STUDY 1 & RECOMMENDATIONS FOR STUDY 2

5.5.1 Summary of Study 1

The primary goal of this first study was to produce a catalogue of the types of undesirable driving practices seen to occur at a small cross-section of junctions shown to have poor accident records prior to the study. In Section 5.1, the four sites selected for this study were each subjected to an individual diagnosis on the basis of the observed information, which was then also compared with the accident records available for the sites. Some sites, or sub-sections of sites, showed good correspondence between the traffic conflicts and the reported accidents, whilst others could demonstrate no such correspondence. This led to the conclusion that the problems whilst negotiating any particular aspect of a junction are highly idiosyncratic and specific to that junction. It was also felt that the situation at each approach road was also different from that at the other approach roads at the same junction and therefore that each should be thought of as, effectively, a separate site.

The data from each junction was combined for the purposes of the inferential analyses which are discussed in Section 5.2. These tests were largely very unsatisfactory, particularly those aiming to find good predictors of approach speeds and incorrect signalling behaviours. For the very reason that the situation at each junction is very different, and that such combination of information is more likely to obscure any site-specific effects, it was concluded that attempting to find general trends in observable junction behaviours may not be most appropriate technique to adopt.

The three main categories of conflict-producing behaviours were discussed in Section 5.3 in reference to the findings of this study and previous research. It was concluded that, although the effect of environmental factors such as those studied here must contribute to these incidents, they must ultimately be a result of driver decision processes, and therefore beyond the scope of such an observation study.

In the previous section of the discussion (5.4), the methodology used in Study 1 was assessed. The main objectives of the first part of the research were realised, and a comprehensive guide to the driving activities at these four junctions was achieved using the variables selected. The main point of contention was over the representativeness of the data, and it was felt that a strategy in which activity from a wider range of circumstances was recorded would have alleviated any such concerns. However, the time restrictions involved dictated that this was not possible, and it is felt that, under the circumstances, the sample is as representative of the population as possible.

5.5.2 Recommendations for Study 2

As already noted, the observation study was unable to provide any information concerning causal factors connected with the types of incidents observed, and it is clear that the second study should aim to uncover these. For example, close-following the vehicle in front was found to be associated with the incidence of rear-end conflicts. Whilst this is not a surprising conclusion, it says nothing about drivers' reasons for following preceding vehicles so closely. In the same way, it is suggested that left-turn and cross-traffic incidents receive the same investigation. It may be remembered that, at the end of the literature review in Chapter 1, it was felt that the most appropriate approach would be one that contained elements of social and cognitive perspectives. As that first chapter concentrated upon the cognitive approaches, the introductory chapter to the second phase of the research will discuss the social aspects of driving before outlining the direction for the second study.

CHAPTER 6:

INTRODUCTION TO STUDY 2

6.0: OVERVIEW

It may be remembered that the literature review (Chapter 1) focused upon issues related to driver behaviour that were of a more cognitive nature. However, the importance of incorporating social aspects of driving with these cognitive elements was noted during the discussion of schemata. Hence, this chapter aims to provide a brief outline of some of the most relevant issues concerned with these social aspects of driving.

In the first section (6.1), the more general issue of social interactions in the driving network is considered, including discussion of a topic that is of direct relevance to the notion of schemata discussed in Chapter 1 - societal norms. This is followed by a brief section on aggression in drivers. Section 6.2 provides a general guide to issues concerned with attitudes, opinions and beliefs and their relationship to actual behaviour. The relevance of these issues to driver behaviour research, as well as several examples of studies incorporating these principles, is discussed.

The next section (6.3) begins with a similar general introduction to two of the most notable attribution theories, before noting the applicability of the attribution approach to this study, particularly in the area of accident causality. Finally, Section 6.4 summarises the main points from the previous sections and discusses the relevance of these issues to the current study. The section ends with a guide to the main aims and objectives of this second phase of the research.

6.1: SOCIAL ASPECTS OF DRIVING

6.1.1 Social Interactions and Societal Norms

Until the early 1980s, the field of driver behaviour research contained virtually no literature that concentrated upon the social interactions of drivers. This was pointed out by Michon (1980), who emphasized the need for more research concerning the social and psychological factors of driving, rather than 'harder' factors such as vehicle or highway design. Many of the early studies which did make attempts to address these issues tended to focus upon identifying personality traits that might be found in 'accident prone' drivers. For example, McGuire (1970) devised a typology of accident proneness which was able to identify five different types of proneness. The conclusions were similar to, and an elaboration of, those arrived by Lauer as long ago as 1937. Lauer argued that it was more appropriate to think of a small group of drivers as being accident-prone, but that consideration must also be given to a much larger group of drivers who could be considered to be more accident-prone for particular periods of time only.

More recently, an increasing number of authors have begun to consider an approach that looks upon the driver as an active participant in a array of social interactions rather than an individual operating in isolation from other road users. Malik (1968) felt that, even though drivers may experience a degree of anonymity whilst alone in their cars, there is a complex web of societal norms (ie. "mutually understood patterns of expectations" - Shor, 1964) that they have in common with other drivers and which must govern their behaviour to a certain extent. In the words of Knapper and Cropley:

"Driving is ... a situation involving social interactions between people, with drivers reacting at least partly to social psychological cues when they make the moment-to-moment decisions involved in controlling the car." (Knapper and Cropley, 1980, p. 419).

Some research designed to investigate the kinds of societal norms discussed here has been carried out. For instance, a study by Doob and Gross (1968) looked at the response of drivers who were stuck behind a non-moving vehicle at an intersection. It was found that older vehicles provoked a much more rapid burst of horn honking activity than did newer vehicles, and the suggestion is that there is an unwritten norm about older cars that provoked this type of reaction. In addition, female drivers were shown to have a longer latency period before using the horn than did males, and younger males were found to be the most impatient group of all.

A study by Shor (1964) demonstrated that confusion may easily arise when normative expectations are not shared. Shor contrasted the norms required to drive in a congested city and a small, uncongested town in America. In order that they communicate their proper intentions to other drivers, drivers in the former place must behave competitively, whilst drivers in the latter place tend to insist on a more courteous approach. Shor hypothesized the situation that would occur if drivers from each place were transplanted into the contrasting place. Unfortunately, it does not appear that any such investigation was carried out, but Shor's approach is interesting from a theoretical perspective and serves to demonstrate that driving norms must exist.

In fact, norms such as these probably exist for a whole range of phenomena. Bliersbach and Dellen (1980) claim that a type of egocentricity is developed by drivers whilst 'realising their driving pattern' (ie. when learning to drive) which serves to ensure that other drivers are perceived from the same point of view as the perceiver and the implicit assumption, therefore, is that these other drivers will respond to situations in the same way as that perceiver. When these other drivers do not respond according to expectation, drivers may produce aggressive or insulting behaviour, an area of social interaction research that has received much attention.

6.1.2 Aggressive Behaviour in Drivers

Whitlock (1971, cited by Hauber, 1980) states that as much as 85% of all traffic accidents result from aggressive behaviour, presumably using a very generalised definition of the term, and Parry (1968, cited by Hauber, 1980) relates that drivers who score more highly on tests of aggression and anxiety are more likely to become involved in road accidents. One of the most interesting studies in this area was conducted by Hauber (1980) who wanted to know if some individuals displayed aggressive behaviour more frequently in driving situations than non-driving situations. Drivers' reactions to an experimenter using a pedestrian crossing were assessed for aggressiveness using certain criteria such as failing to stop, gesticulations and comments made to the experimenter, and use of the horn. The results showed over 25% of drivers displayed some aggressive behaviour and also that younger drivers were generally more aggressive than older drivers. No significant differences between male and female drivers were noted.

The same drivers were then traced using their licence plates and those in possession of telephones called twice in succession by the experimenter, who claimed to wish to speak to a fictitious person. The 'phone calls were made as lengthy as possible, and the amount of abusive behaviour provoked in the subject was recorded. Indeed, a certain proportion of the aggressive drivers also behaved in a similar manner on the telephone (10.9% of all drivers receiving 'phone calls), but as Hauber points out, the actual numbers involved were so small that it would be dubious to make anything other than tentative conclusions about this. Some subjects were also personally interviewed and, once again, aggressive behaviour was monitored. However, no significant relationship between behaviour during the interviews and during the previous two studies was noted.

6.2 ATTITUDES, OPINIONS AND BELIEFS

6.2.1 Definitions of Attitudes, Opinions and Beliefs and Their Relationship with Actual Behaviour

Michon (1980) pointed out that an area of research that demanded more attention was that which focused upon the motivational factors implicated in social interactions amongst drivers, and suggested that it might be possible to:

"...teach better traffic behaviour if we could identify the attitudes and opinions in the area of interpersonal relations, out of which observable driver behaviour arises." (Michon, 1980, p. 402).

However, before looking at the contribution that studies of attitudes, opinions and beliefs might be able to make to the understanding of social interactions amongst drivers, it is necessary to define exactly what is meant by those terms. Oskamp defines an attitude as:

"...a readiness to respond in a favourable or an unfavourable manner to a particular object or class of objects." (Oskamp, 1977 cited by Gergen and Gergen, 1981, p. 121).

Therefore, attitudes must have a topic, be judgemental or evaluative (ie. the topic must be seen as 'good', 'bad' or somewhere in-between) and be relatively long-lasting (Gergen and Gergen, 1981).

In addition, attitudes can be said to consist of three components: the cognitive; the affective; and the conative. The cognitive component contains all the perceptions and concepts the person possesses about the topic. The affective component adds the person's feelings about the topic to the cognitive component, ranging from the feelings of 'liking' or 'loving' associated with positive attitudes, to the 'disliking' or 'loathing' connected with negative attitudes. Finally, the conative component consists of the actions the person wishes to perform in response to the topic.

Opinions are often confused with attitudes, and the distinction may be quite fine in some cases. Opinions can best be thought of as sub-sets of attitudes and relate to specific manifestations of attitudes. For example, a person may hold an opinion about a particular deterrence measure for drink-driving, but the accompanying attitude will be concerned with drink-driving in general. Beliefs are more clearly differentiated from attitudes and can be thought of as statements about a topic that a person thinks is true. This is rather like the cognitive component of an attitude and beliefs may be thought of as being attitudes without the affective or conative components.

A major area of debate within the realm of attitudes and attitude measurement concerns the degree to which attitudes can be used to predict behaviours. Wicker (1969) carried out an extensive review of the literature on attitudes and concluded that:

"...taken as a whole, these studies suggest that it is considerably more likely that attitudes will be unrelated or only slightly related to overt behaviours than that attitudes will be closely related to actions." (Wicker, 1969, cited by Gergen and Gergen, 1981, p. 193).

This view of the attitude-behaviour problem remained prevalent for several years, until an alternative approach, first suggested by Fishbein (1967) and developed by Ajzen and Fishbein (1977), was expounded. These authors emphasized the importance of 'intention' in the model and suggested that, assuming responses to be honest and no intervening factors are present, behaviour and intentions will be highly correlated. However, intentions are not solely governed by attitudes, and the additional factors 'normative beliefs' and 'motivation to comply', both social pressure factors, were incorporated into the model. Normative beliefs concern what people feel they *should* do in a particular situation, and this will be affected by the views of the peer group. The extent to which the person is motivated to comply with other people's feelings also contributes to the intention to act. Fishbein's model states that the intention to participate is dependent upon the 'sum' of the attitude and the normative beliefs, weighted by the motivation to comply.

It appears that attitudes can only be considered to affect behaviours indirectly. However, if care over the measurement techniques is taken, reasonably high correlations, such as the 0.40 reported by Ajzen and Fishbein (1977), may be found. Several researchers have used Fishbein's model to assess the attitude-behaviour relationship of a wide variety of topics, and many of these projects, such those looking at reactions to nuclear power proposals (Bowman and Fishbein, 1978) and church attendance (Brinberg, 1979), have demonstrated a good predictive relationship between attitudes and the resulting behaviours.

6.2.2 Attitudes, Opinions and Beliefs in Driver Behaviour Research

An early study designed to investigate the attitudes of drivers was conducted by Goldstein and Mosel (1957). These researchers attempted to identify the underlying variables or dimensions of those attitudes, and defined four main areas of investigation: appreciation of hazards; social responsibility or conformity; attitudes towards the vehicle; and attitudes towards speed and speed limits. The inventory, derived from the literature, contained 186 items before a factor analysis technique was used to reduce them to five main factors: attitudes towards competitive speed; attitudes towards other road users; attitudes towards the police; attitudes towards the vehicle; and finally general attitudes concerning safety issues. The factors were then correlated with various demographic variables and, amongst other results, found that for female drivers, the number of violations was negatively correlated with a preference for slower driving. In addition, male drivers were found to have a greater respect of rules and regulations with increased age.

Another early study looking at drivers' attitudes was performed by Case and Stewart (1957). Their driving attitude scale was developed from informal interviews with 300 habitual traffic violators, from which a number of multiple-choice items were derived. After reducing the scale to 55 items, Case and Stewart tested it on a number of subjects and found that many of the items were able to discriminate between subjects classified in terms of the number of citations received. In addition, some items were found to differentiate between groups of individuals classified in terms of their reported speed selections under various conditions.

A comprehensive study of driver attitudes was carried out by Knapper and Cropley (1980) who used information derived from interviews with road safety experts and from group interviews with members of the public to develop a questionnaire. The questionnaire consisted of four parts: 99 items on traffic hazards actually experienced by the interviewees; 53 opinion statements about driving; 33 adjective pairs used to describe dangerous drivers; and finally six brief scales designed to assess subjects' reactions to near-collisions. Once again, factor analysis techniques were used to reduce the number of items to more manageable formats.

One of the most interesting findings that emerged from the analysis was the fact that the respondents tended to view other road users, particularly other drivers, as major sources of risk. These other drivers were generally seen as being more careless, aggressive, selfish and arrogant and Knapper and Cropley concluded that drivers tend to view objective factors, such as vehicle maintenance and road conditions, as being more pertinent accident causation factors. Such factors cannot have been based upon directly-observable characteristics and it appears that the attitudes and values of other drivers were being inferred from some properties of observable behaviour. Knapper and Cropley concluded that other drivers are judged in highly subjective ways, and that these judgements reflect the attitudes, preconceptions and prejudices of the judger. The authors were quite critical of their own work, feeling that it was:

"...too simplistic an approach, as is that of cataloguing 'good' or 'bad' driver behaviours, listing personality types of drivers with different kinds of driving histories... It needs to be understood that a set of informal or societal norms is at work..." (Knapper and Cropley, 1980, p. 433/4).

A more recent study by Wilson (1987), expanding upon the work of Knapper and Cropley, attempted to gain a more thorough understanding of the underlying components of the driving task under normal conditions, comparing this information with the attitudes and beliefs that drivers have about that task. The first part of the study involved two observers rating the performances of a group of subjects who were asked to drive around an urban and rural test route. Subjects were then asked to respond to a variety of statements regarding general driving, dangerous driving, and dangerous driving situations. The rating scales were then reduced to a series of underlying components concerned with the driving task and, by comparing the factor structures produced, the drivers' actual performances and their opinions were compared.

The relationship between performance and opinion was found to be rather complex, and some aspects were found to be in agreement whilst others were not. In addition to the discovery that drivers rated their own performances more favourably than did the observers, it was found that certain groups of drivers were able to accept their own risk-taking driving components but generally failed to view them as dangerous. It was concluded that risk was perceived in terms of potential risk to the individual rather than as a potential accident, and therefore risk to others.

6.3: ATTRIBUTIONS

6.3.1 Attributions of Causality in a General Context

One of the key topics within the general field of Social Psychology is that dealing with the ways in which people attribute causality to events. The issue centres around attempts to understand why people act in certain ways, and which factors contribute towards developing a "causal analysis of the social world" (Baron and Byrne, 1984). In addition to factors such as physical appearance and direct questioning, the main source of information about others' motives and intentions is from their overt behaviour. However, overt behaviour may not always be a good predictor of "true" personal characteristics, and here complications lie. Several theorists have attempted to overcome these difficulties, one of the most influential being the theory of 'correspondent inference' proposed by Jones and Davis (1965). These authors suggested that people rely upon three components when judging actions: whether the action was freely chosen; whether the action produced non-common effects (ie. ones that could not have been obtained using other courses of action); and the perceived social desirability of the actions.

Jones and Davis' theory can be thought of as dealing mainly with the ways in which people use others' overt behaviours to infer their long-term personal dispositions. An alternative approach, concentrating upon attributing behaviour as a function of internal, external or both causal factors, was devised by Kelley (1972) and also contained three main components: consensus; consistency; and distinctiveness. The first of these concerns the extent to which others react in a similar manner to the actor, the second refers to the degree to which the actor responds in the observed manner on other occasions, whilst distinctiveness is the extent to which the actor responds to different situations in the same manner as that observed. Kelley suggested that observers are more likely to attribute internal causal factors to another's behaviour if consensus is low, consistency is high and distinctiveness is low. Conversely, external factors will be more likely to be invoked if there is perceived to be high consensus, consistency and distinctiveness. Although there is some evidence (eg. Ferguson and Wells, 1980) to suggest that people do sometimes attribute causality in a way that is consistent with Kelley's theory, other research has shown that some modifications may be necessary. For example, more recent work by Kelley (Wimer and Kelley, 1982) also implicated factors such as the complexity of the causal process, whether 'good' or 'bad' outcomes are produced (with similarities to Jones and Davis' 'social desirability' factor), and the extent to which conscious desires and motivations contribute to attributions.

Attribution theories general assume that people attribute causality in a highly rational manner, but it should be noted that there are many potential sources of bias in the attribution process, regardless of which theory is considered. According to Baron and Byrne (op. cit.), dispositional factors are the main source of bias. In other words, there is evidence (eg. Yandrell and Insko, 1977, cited by Baron and Byrne, 1984) to suggest that people display a tendency to attribute actions to intrinsic, personal sources, rather than taking the context of the situation into account. A related phenomenon is the 'actor/observer' effect noted by Jones and Nisbett (1971), who felt that the perpetrator of an action (the actor) makes causal attributions in a different manner to those made by observers. The main difference concerns the availability of salient information, the actor being aware of the situational factors influencing their own actions, but the observer lacking this information and having to resort to making inferences on the basis of dispositional characteristics. However, it has been shown (eg. Gould and Sigall, 1977, cited by Baron and Byrne, op. cit.) that observers are more likely to implicate situational factors when induced to empathise with the actor.

Another potentially major source of attributional bias is referred to as the 'self-serving' bias (Miller and Ross, 1975, cited by Baron and Byrne, op. cit.) and concerns the strong tendency for people to take personal credit for favourable outcomes, yet attribute causality to external sources when things go wrong. Baron and Byrne (1984) suggest that this may often be due to the desire to retain good self-esteem. An alternative approach proposed by Weary and Atkin (1981, cited by Baron and Byrne, op. cit.) is concerned with self-presentation and in which these self-serving biases are felt to be reflecting the desire to present a favourable image to others. A study by Greenberg, Pyszczynski and Solomon (1982, cited by Baron and Byrne, op. cit.) investigating attributions for success or failure in an intelligence test suggested that, while desires to protect both self esteem and self-image were able to produce a self-serving bias, the effect of the former was found to be the stronger.

6.3.2 Applications to Driver Behaviour Research

One of the main applications of attribution theories to the study of driver behaviour is in the realm of accident causation. An early study of this nature was performed by Shaver (1970), who looked at differences in attributions of accident responsibility. One of the main findings was the tendency for perceived personal similarity between the observer and the 'actor' in the scenarios presented in the questionnaires to have the effect of decreasing the former's attributions of responsibility to the latter, in addition to increasing their assignments of carefulness. A study of a more general nature was carried out by Banchevska (1980), who surveyed a large number of Australians asking for their attributions regarding the major causes of road accidents. The most cited causes were found to be excessive speed, excessive levels of intoxication and disregard of road rules.

This latter study highlights the necessity to determine exactly what are the 'true causes' of accidents that should be investigated. It is argued that the types of factors cited by Banchevska's subjects are merely symptoms of the true causes. For example, a particular accident may have been 'caused' by excessive speed in the sense that, had the driver driven more slowly, the accident would not have occurred. However, the 'root cause' of the accident surely rests with the driver who selects the speed at which the vehicle was travelling. It is argued that, for the purposes of the current research at least, it is these *underlying* causes that must be investigated if a thorough understanding of accident causation is to achieved. The relevance of this, and of the other aspects of driving discussed in this chapter, will be discussed in the next section.

6.4: SUMMARY OF MAIN POINTS FROM CHAPTER 6 & APPLICABILITY TO AIMS & OBJECTIVES OF STUDY 2

6.4.1 Summary of Chapter 6 & Relevance of Social Aspects of Driving to the Current Research

The first section of this chapter (6.1) focused upon the issue of social interactions in drivers, and briefly touched upon the topic of 'accident proneness'. Although the study of individual differences in terms of 'proneness' failed to produce any reliable predictive tests, some authors feel that an approach emphasising the more transient concept of accident liability may be more productive. For example, Grayson and Maycock (1988) introduced their paper on this topic by stating that:

"...the study of the way in which individual road users differ in their liability to have road accidents would be one of the best documented and active areas of traffic safety research." (Grayson and Maycock, 1988, p. 234).

Clearly, if the factors associated with differential accident involvement could be uncovered by a reliable and systematic method, accident liable drivers could then be identified, preferably at an early stage of their driving history. However, the likelihood is that such increased liability for any individual will not be consistent over their driving history, unlike the assumed intrinsic nature of accident proneness, and identification of these factors may be complicated by the necessarily retrospective studies. On the other hand, the suggested more transient nature of accident liability implies that it will be applicable to corrective training methods, if the specific 'deficiencies' in these liable drivers could be identified.

A related topic is that of accident culpability. By implication, the driving style of those involved in higher numbers of accidents (and therefore more 'liable') must display characteristics that predispose these people to increased accident likelihood. However, it is argued that it would also be of use to study the factors more directly associated with accident causation by concentrating upon those people felt to have been primarily responsible for accidents they have been involved in.

The second section of this chapter (6.2) discussed attitudes, opinions and beliefs and the ways in which they can be applied to the field of driver behaviour research. In this context, it is suggested that opinions about many aspects of driving at junctions may be implicated in such phenomena as accident liability and accident culpability. Assuming that there is some relationship between opinions about driving and driving style, it is felt that such factors may be able to play a major role in the formation of the following study. The previous section (6.3) discussed general attribution theories before noting some studies that have used such principles in the area of driver behaviour research. For the purposes of the current study, it is felt that the study of attributions of accident causality may be able to provide additional clues as to the underlying causes of accidents to supplement those points discussed above.

The first chapter concentrated more upon the cognitive aspects of driving, although the discussion of schemata in Section 1.7 integrated cognitive and social components. It should be clear, then, that it is this type of integration of the cognitive and social interaction approaches that is required. As Michon (1980) put it, progress will not be made until researchers can:

"...succeed in formulating a cognitive framework in which the relevant knowledge about perceptions and attitudes, and the observable behaviour patterns connected with them, can be explained in a way that is understandable to the average road user." (Michon, 1980, p. 403).

The approaches described in this section clearly have the potential to uncover many aspects of the underlying structures of people's driving, and therefore the discovery of components which contribute to differential accident involvement has considerable implications for driver training. The following section will map out the main aims and objectives of the second study.

6.4.2 Aims and Objectives of Study 2

The previous section noted the need for an integration of cognitive and social approaches to driving behaviour. In Section 1.7 of the literature review, this was touched upon in the discussion of schemata and it is part of the aim of this second study to uncover some of the more basic general schemata about driving at junctions held by members of the general driving population. The previously-cited study (see Section 1.4.4) performed by Harano, Peck and McBride (1975) investigated the ability of demographic details, performance scores on psychometric tests (such as the embedded figures test) and a number of driving variables (such as mileage) to predict levels of accident-involvement. It is suggested that the second part of the current study should aim to undertake a similar study, but concentrating more upon socio-cognitive aspects of driving, such as responses to opinion statements or perceptions of hazardous situations.

It is felt that these types of responses would be best achieved by investigating the ways in which drivers perceive driving at junctions, including details of their own driving style and that of others. The most appropriate way of doing this involves asking drivers to report their beliefs and opinions about their own, and others', driving styles at junctions. In addition, it is felt that drivers' perceptions of the risk inherent in certain driving practices at junctions may be able to highlight further differences between groupings of drivers.

In addition to opinions and beliefs about driving at junctions, it is felt that there are other potentially important issues that should be explored. For example, if questions concerning people's opinions about others' driving are asked, it makes sense to determine those types of behaviours that are performed by these drivers themselves. In addition, it would be of use to have some record of these drivers' actual driving styles, as well more basic descriptive information. These issues will be dealt with in more detail in the next chapter.

In general, it may be considered that the ultimate aim of this type of research is to contribute to a body of knowledge that may help to reduce the number and severity of road accidents, and it is therefore argued that it would be particularly useful to investigate any factors associated with known differences between the type of groups of drivers outlined in the previous section (eg. 'liable drivers', 'culpable drivers' etc.). The next chapter details the methodology adopted in this second study.

CHAPTER 7:

METHODOLOGY FOR STUDY 2

7.0: OVERVIEW

This chapter details the methodological considerations and procedures adopted for the second phase of the research. Section 7.1 summarises the findings from the survey of accident records and the observation study, pointing out the ways in which this information may be able to contribute to this study. The following section (7.2) details an additional method of item generation that was used - social information generating groups (SIGGs), in which a number of drivers were allowed to freely discuss aspects of driving at junctions.

Section 7.3 describes the design considerations for this study, including sections on the applicability of the questionnaire technique to the objectives of the second phase and detailed sections on the sampling techniques used. This is followed in Section 7.4 by a description of the development and design of the questionnaire with the justifications for the inclusion of each group of questions. Section 7.5 outlines the procedure adopted for the pre-test and pilot surveys, along with details of modifications made to the questionnaire as a result of these surveys. Finally, Section 7.6 describes the procedure adopted for the main survey and treatment of the questionnaires upon return.

7.1: SUMMARY OF FINDINGS FROM ACCIDENT STATISTICS & STUDY 1

7.1.1 Summary of Accident Statistics

Each of the four junctions had their own peculiarities when time of day, month and year effects were studied, but none revealed anything of importance and there were certainly no traits common to all sites. The most predominant type of accident occurring at all of the sites was that which resulted from one vehicle pulling out into the path of another vehicle (or several vehicles). There also appeared to be three distinct forms of this manoeuvre which should not be treated as equivalent. The first type occurred at Sites 1 and 4, and involved vehicles turning from a side (minor) road onto a major road, in the path of vehicles already travelling on that major road. At Site 4, one of the two main sources of accidents, along with the one mentioned above, occurred as a result of vehicles turning from a major road, across the path of vehicles travelling in the opposite direction on that same road, into a minor road. Of a similar nature is the main type of accident at the two roundabouts (Sites 2 and 3). This involved vehicles pulling out from the entrance roads into the path of vehicles negotiating the roundabout. It is argued that the errors made in each of these three accident types is fundamentally the same, the driver either failing to notice a vehicle about to cross the intended path of their own vehicle or incorrectly judging the speed and/or distance of that same vehicle.

The other main category of accident was the rear-end shunt, which happened on the minor or entrance roads at all bar Site 1. Of a slightly different nature is the type of rear-end shunt occurring in queues on the main roads formed by vehicles wishing to turn into a side road. This was most apparent at Site 4, although this type only accounted for 4.25% of all accidents that were covered by this study. It may be argued that the processes leading drivers to commit the rear-end-shunt error is identical for the two circumstances outlined above, but this is certainly a potential topic for the questionnaire.

The final general accident category was that resulting from drivers losing control of their vehicles. Unfortunately, in the vast majority of cases, the information contained within the accident records was insufficient to enable any clear patterns to be discerned. However, many of these cases resulted from driving in a manner that was inappropriate to the condition of the road surface, particularly on wet road surfaces.

7.1.2 Summary of Study 1

The main findings from the first study have previously been summarized in Section 5.5.1, but the main points will be re-stated here. The descriptive statistics for the four junctions studied revealed that errors in the form of traffic conflicts were observed in around 7% of all vehicles, with cross-traffic and left-turn conflicts accounting for the majority of cases. The inferential analyses showed that several factors were related to conflict-involvement, including approach speed, gap acceptance time, following distances and the presence of other vehicles. In addition, appropriate signalling behaviour was found to be lacking in a quarter of drivers, with left-turns being the manoeuvre producing the worst incidence of correct communication via use of indicators.

The first study was able to provide some useful information regarding the behavioural factors connected with driving error production at junctions. However, it was also felt that some integration of these behavioural items with attitudinal and driver-related items was required to provide a more complete description of the process of driving at junctions, and the next section describes the method by which the majority of these latter class of items was derived.

7.2: SOCIAL INFORMATION GENERATING GROUPS

7.2.1 Background

One potentially profitable method of gathering information about any topic involves allowing a group of people sampled from the population under study to discuss that issue, occasionally prompted by key questions or statements. The researcher is then better able to distinguish between issues that are relevant to the people in question from those that are not so relevant. These social information generating groups (SIGGs) have previously been used by Wilson, W.T. (1973) in studies concerned with transportation planning and telecommunications. Since then they have been used to good effect in driver behaviour studies by researchers such as Wilson, P. (1987). For the purposes of the current research, it was thought that these SIGGs could be used to generate items for the second study from statements made by the participants that were clearly relevant to the topic in question.

7.2.2 Methodology and Procedure

It was decided to have groups of four members (as this number had worked well in the aforementioned 1987 Wilson study) and as many groups as necessary to avoid needless repetition, finishing when the points made in the discussions became highly derivative of those made by previous groups. Advertisements for volunteers (see Appendix R) were placed on noticeboards at various locations around Cranfield Institute of Technology, the only requirement being that participants held current full driving licences. The discussants were placed in groups in the order in which they responded to the advertisement, although some adjustments had to be made to accommodate differences in availability.

Each discussion group began with the author introducing himself and giving a brief summary of the research and the purpose of the SIGG. The participants were then asked if they had any objection to the discussion being recorded. After switching the tape recorder on, the group was asked the general introduction question:

"What factors are important to you when approaching a junction?"

and then allowed to discuss the question amongst themselves. On occasions when the conversation appeared to be faltering, the researcher asked another general question from a prepared list that appeared relevant at that stage of the discussion. However, it should be pointed out that, with the exception of moments during the second group's discussion, this was largely unnecessary as the participants were highly loquacious. After the allocated time period (half an hour) had elapsed, the discussions were terminated, the participants thanked for their contribution, and paid the five pounds participation fee. However, one of the groups (the third) carried on their discussion long beyond the half hour limit, having become extremely involved in the topic.

After three discussions had been completed, it was decided that the information generated was sufficiently similar to not warrant participation of further groups. In total, twelve discussants were involved in the sessions, four in each of the three groups. Only three of the participants were female, and the age range covered was from 19 to 50. This does mean that the people used in the discussion groups were not representative of the driving population, but the exploratory and qualitative nature of this stage of the research reduces the importance of this minor shortcoming.

On completion of the SIGGs, the discussions were transcribed from the tape recordings. On each occasion that a new concept arose in a discussion, it was noted down in a manner that most closely reflected the original statement without including any irrelevant material. The items derived from each of the three SIGGs can be found in Appendix S. Each item was then considered for its' relevance and potential inclusion in the questionnaire.

7.3: DESIGN CONSIDERATIONS FOR STUDY 2

7.3.1 Use of the Questionnaire Method of Data Collection

It was noted in Section 2.3.1 that, whilst the questionnaire method was unable to answer the requirements of the first study, this technique is able to gather information concerning drivers' self-perceptions and opinions of the driving of others, and is therefore ideally suited to the requirements of the second study as outlined at the end of the previous chapter. The main advantages with questionnaires includes the fact that a relatively large amount of information can be gathered from a large sample in a more time and cost-effective manner. For the purposes of the current research, a relatively large sample must be obtained to include a suitable number of cases belonging to small sub-groups (such as rear-end collision-involved drivers) to allow reliable statistics to be performed.

7.3.2 Sampling Considerations: Target Population

The main purpose of the questionnaire study was to compare junction-accident-involved drivers and non-accident-involved drivers on a variety of items related to junction negotiation strategies and attitudes. Therefore, the obtained sample had to include representatives of both groups of drivers. Clearly, the main consideration when selecting the target population is to decide exactly who the sample is to represent, ie. the people about whom inferences are to be made. The questionnaire survey was designed to be used as a supplement to the observation study, and therefore it seemed logical that the group of drivers to be questioned should be as representative of those who featured in the video recordings as possible. On this basis, it was decided that the sample should be obtained largely from the Milton Keynes area. However, by having additional samples from other areas any differences between drivers based in different areas could be investigated. Obviously, any inferences made from the findings of this survey will be limited to the drivers from the areas in which it was carried out, and any inferences beyond these limits should be made with extreme caution.

Although receiving completed questionnaires from the driving population in general would produce a certain number of drivers involved in accidents at both junctions and other locations in general, it is clear that non-accident-involved drivers would be over-represented in the sample. Therefore, it was decided that an additional sample was required in which there was a considerably higher proportion of accident-involved drivers to increase the number of these respondents. The most comprehensive source of this type of information is police accident records, and contact was made with Thames Valley Police divisions at Milton Keynes and Aylesbury asking for permission to access these records for names and addresses of accident-involved drivers in these areas (see Appendix T for a copy of the contact letter). Permission to do this was granted by both Chief Inspectors, and the sampling of these subjects is described in Section 7.2.4. However, at the time at which the sampling was made, the accident records department at A-Division headquarters in Aylesbury was being re-organised and it was not possible to take a sample from their records.

7.3.3 Sampling Considerations: Sampling Strategy

7.3.3.1 Sample from Police Records

For mainly practical reasons it was decided to concentrate on drivers who had been involved in accidents in the 24 months prior to the sampling. By delving further back into accident history, the respondents' recollection of the accident is likely to have deteriorated somewhat and also the likelihood that they have moved house, and will therefore not receive the questionnaire, increases.

The format for sampling involved studying the record for each accident in turn, looking out specifically for accidents at junctions. For all such accidents, the name and address of the person felt (by the police) to be responsible for the accident was noted. Care was taken to ensure that none of these drivers were involved in accidents that produced fatalities, as sending questionnaires to people involved in such accidents was considered to be insensitive and have serious ethical implications. This does mean that a potentially important category of accidents was excluded from the study. In addition to the severity of injuries produced, it is possible that accidents producing fatalities have different antecedent characteristics and it should be stated that this is a shortcoming of the sampling strategy adopted. However, it was felt that the ethical problem was of greater importance than the range of phenomena covered, and all conclusions concerning the accidents studied in the subsequent chapters should take this into account.

A relatively high proportion of the accident records produced no name and address as the guilty party had not stopped and insufficient details had been recorded to enable that person to be traced. In total, the Milton Keynes police records sample produced a total of 730 names and addresses, the accidents covering the period from January 1988 to December 1989 inclusive. An assumed return rate of 25% would therefore provide data for just over 180 accident-involved drivers.

7.3.3.2 General Sample

The most obvious source of names and addresses for drivers in this country is the DVLA (the Driver and Vehicle Licensing Authority) who had co-operated with a previous researcher (Brooks, 1987) by providing a list of randomly-sampled names and addresses for a mail-shot questionnaire. The DVLA were again prepared to allow access to their records, but delays resulting from changes to the computer system at the time the sample was required meant that they were unable to offer the necessary support and an alternative source for the data had to be found. Fortunately, the Transport and Road Research Laboratory hold a 1% sample from the DVLA records, and access to this sample was granted. In total, over 7200 randomly sampled names and address of currently registered drivers were provided to the three researchers requesting them: 4800 from the United Kingdom in general; 2400 from the Milton Keynes area. The sample was then randomly split between the three researchers for use on the individual projects. For this study, 1500 general sample and 500 Milton Keynes area addresses were deemed to be sufficient to produce an adequate sample size.

7.3.4 Method Of Questionnaire Distribution

There are two basic methods by which a survey of this nature could be conducted: using one of the interviewer-administration or self-administration techniques. The main advantage of the former is that it is always certain exactly who is answering the questions. When questionnaires are given to potential respondents to complete in their own time, it can never be guaranteed that the questionnaire is completed by the person it was intended for. Additionally, items which are knowledge-based, requiring immediate, on-the-spot, answers cannot be incorporated in to the questionnaire. Allowing the respondent to take the questionnaire away with them allows for the possibility of researching the answers to such items. However, the latter method has the considerable advantage of allowing respondents to complete the questionnaire in their own time and is therefore likely to reduce the number of refusals. The large sample intended for the current study prevented the interviewer-administered method from being used although this problem could have been overcome if a team of trained interviewers had been available. However, this was considered to be beyond the resources of the project.

A postal survey technique was adopted as this method usually provides a relatively high return rate, whilst cutting down on administration time. Although distributing the questionnaires personally (complete with a freepost return envelope) may yield higher return rates due to the increased personal contact, it was decided that the difference in methods of administration for the two main samples would provide an additional difference between these samples and make interpretation of the results more open to question. Obviously, the potential respondents obtained from police records could not be approached personally as time restrictions would prevent calling round to over seven hundred houses, some of them quite some distance from Milton Keynes. Under the circumstances, it was decided to distribute all questionnaires by post.

7.4: DESIGN CONSIDERATIONS FOR THE QUESTIONNAIRE

7.4.1 Section 1: Demographic Details

The need for a set of questions relating to demographic details should be obvious. The researcher is usually looking to obtain a representative sample of a particular population, and the inclusion of the basic demographic items such as age, sex and occupation allow for comparisons between the obtained sample and the target population to be made. For the purposes of this research, a number of additional items were required that record details of important driving demographics such as the type of vehicle driven, the period of time a person has been driving regularly, the amount and type of training received, the amount of exposure to the road environment each driver receives and a measure of the total annual mileage. These are all factors which may be implicated in the way in drivers differ in their responses to other items in the questionnaire.

Many of these items were taken directly from the author's previous research (Bottomley, 1987), although the items on training were based on those used by Crick (Crick & Guppy, personal communication, 1990), and the questions asking for the relative amount of time spent on familiar/unfamiliar roads and on rural roads, urban roads and motorways were derived from Perry's (1987) adaptation of Wilson's (1987) driver information questionnaire.

7.4.2 Section 2: Accident Details

As the 'experimental group' of respondents were to be drivers who had been involved in accidents at junctions whilst driving and were also, at least partly, at fault, the accident section needed to concentrate on these issues. The first group of items related to the total number of accidents the respondent had been involved in, followed by the number of these accidents that occurred at junctions, along with the number of these latter accidents the respondent felt they were responsible for. It was decided that a more detailed description of junction accidents had to be elicited, so a series of more in-depth questions were devised, including details of the type of vehicle driven, the time of day, the type of location, whether this location was familiar to the driver, and finally an open-ended question asking for a brief description of the accident.

The main purpose of asking these questions was to enable information relating to drivers involved in different kinds of accidents at different types of locations to be isolated. Additionally, it was thought that this level of information could only be asked of one accident, so respondents were asked to report on their most recent junction accident, as this is the one for which they are most likely to provide accurate information. If a respondent had never been involved in an accident at a junction, but had been involved in some accident (again whilst the driver of the vehicle), they were asked to provide details of their most recent non-junction accident, as it was felt that the additional information may provide the material for a useful comparison between drivers involved in junction and non-junction accidents.

One of the most important aspects of this section of the questionnaire was felt to be the driver's perceptions of the causes of the accident and where the responsibility for that accident lies. The main items in this section were derived from a questionnaire devised by Clay (1987) for a study looking into accident-involved drivers' attributions concerning the causes of their accidents. Respondents use a five-point scale to indicate the extent to which they feel the accident was attributable to their own driving, someone else's driving, another non-driving road user, the road or weather conditions and mechanical failure. The usefulness of these items is that they allow a driver who realises s/he was at fault to blame an 'external' factor (such as the weather) when in fact the accident was truly attributable to that person not driving in a way that was suitable for the prevailing conditions. It is thought that having such an 'escape clause' means that accident-responsible drivers will be more honest about the accident's true cause. However, it was felt that this potentially rich source of information was not being sufficiently tapped by the items as they stood, and hence a number of additional items, such as 'fatigue', 'poor road design' and 'poor visibility' were included. Two supplementary items to this section ask if the respondent feels if they, or someone else, could have done anything to prevent the accident from occurring. These are included to provide a further guide as to the nature and cause of the accident according to the respondent.

7.4.3 Section 3: Likelihood of Driving Behaviours Resulting in an Accident

The main purpose of this section was to identify those driving practices at junctions that respondents perceive as being dangerous. It was felt that this knowledge may help to identify crucial differences between accident-involved and non-accident-involved drivers and enable the responses to other items to be viewed in perspective. The items themselves were partly derived from the observation study ('Drivers not indicating correctly' for example) and partly from the Social Information Generating Groups (eg. 'Motorcyclists going quickly through junctions'). In general, the items concerned with social interactions between drivers tended to come from the discussion groups, whilst the purely behavioural items came mainly from the observation study.

In her study on driver typologies, Wilson (1987) used a similar selection of items, although respondents were asked to recall how frequently they witnessed each one. This technique was also utilised in the previous study by the author (Bottomley, 1987). However, rather than asking respondents how often they witness these behaviours, it is argued that it is far more relevant to determine how dangerous each behaviour is perceived to be, as this must have some reflection on the way respondents deal with these situations when they arise. For example, if a respondent feels that a driver not indicating correctly runs a high risk of resulting in an accident, it follows that they should be less likely to engage in that behaviour themselves. However, this may be assuming rather too much as the relationship between attitudes and behaviour remains largely unproven (see Section 6.2.1 in the previous chapter). Despite this reservation, it is felt that there is sufficient scope for comparisons between these items and those contained within other sections to justify their inclusion.

Given that it is the level of danger inherent in each situation that is important, it was felt that the most appropriate way to present these questions would be to ask respondents to rate the probability of each situation resulting in an accident. An early study utilising a probability scale was conducted by Klette (1972, cited by Bragg and Cousins, 1977) who used a discrete category probability scale, although this type of scale proved difficult to analyse and interpret. A more useful scale is the logarithmic probability scale devised by Bragg and Cousins (1977) using a continuous scale divided into equal logarithmic intervals ranging from 1/1 to 1/1,000,000. Validation studies confirmed that subjects could reasonably accurately assess their chances of being arrested using this scale (Cousins, 1977). More recently, slight variations on the log. probability scale have been used to determine the perceived chances of being arrested whilst under the influence of alcohol (Guppy, 1984) and the likelihood of being involved in an accident whilst overtaking in several alternative scenarios (Harris, 1987).

For the purposes of this study, it was decided to utilise the log. probability scales as originally used by Bragg and Cousins, as the methodology to be adopted required no changes to be made. However, results from the first 'pre-test' stage of the questionnaire revealed that respondents had difficulty in answering these items, and many reported selecting arbitrary values. In light of this, it was decided to retain the question and the seven-point format, but to replace the scale with a simpler version with the poles labelled 'Highly Likely' and 'Highly Unlikely'.

7.4.4 Section 4: Descriptions of Driving Style

The section originally asked drivers to assess their own driving at junctions in terms of a number of skills it was felt a competent junction-negotiator must possess, derived from the SIGGs and the literature. However, an early pre-test stage revealed the fundamental flaw in the logic behind this section. It seems obvious that drivers feel that they are reasonably skilful in these respects - they get evidence to suggest that this is true from the feedback they receive every time they drive through a junction and do not have an accident. Also, most drivers realise that whilst this may be generally true, there will be occasions on which they have lapses, whether resulting in a collision or not. In other words, no driver is perfect. It is not surprising, therefore, that the vast majority of respondents (approximately 80% for each item) ticked the 'Mostly' category when asked how often they were able to demonstrate each of the skills listed.

Attempts were made to re-word this section or change the scale, but all versions had logistical problems. As this section was attempting to derive some form of driver self-assessment in terms of such factors as attention, reactions and anticipation it was concluded that the ideal solution would be to utilise some form of self-assessment technique that has been shown to be effective when used in previous research.

An ideal example of this was devised by Wilson (1987), who reduced a series of forty adjectives into eighteen bi-polar descriptions of driving on which subjects describe their own driving using five-point scales. The items themselves had been derived from previous research (Wilson, 1980) and of the original item pool, those that showed variability in responses in a pilot study were retained. More recently, Guppy, Wilson and Perry (1990) have applied principal components analysis techniques to reduce the scales to a smaller number of dimensions of driving, which have then been studied in relation to accident experience and other phenomena. It should be noted that Wilson also used the adjectives to obtain information on respondents' perceived characteristics of dangerous drivers, but this was not felt to be sufficiently relevant to the current research to warrant addition of a further section.

7.4.5 Sections 5 & 6: Statements About Driving at Junctions

It was noted at the end of the previous chapter that one of the ways to study generalisable schemata concerned with driving at junctions would be to investigate the differences in attitudes, opinions and reported behaviours of a variety of sub-groups. Therefore, these sections of the questionnaire contained a series of opinion and behavioural statements specifically about driving at junctions. The items were once again derived from the Social Information Generating Groups, whilst some others were modified from Wilson's (1987) questionnaire.

In addition, it was felt that the two general classifications of behaviour identified in the observation study as being particularly problematical, close-following/rear-end shunting and pulling out into the path of another vehicle/failure to 'give way', should to be studied in greater detail to determine factors that may be associated with these behaviours. More specifically, if the extent to which each of a number of factors associated with drivers' approach strategies and decisions to pull out can be determined, it is argued that the reasons for these specific failures in junction negotiation can be more clearly understood. Therefore, items pertaining to these two manoeuvres were included in the questionnaire, being partly derived from the observation study, and partly from the other sources already noted.

The items were then divided into two sections. The first section contained more general items, not specifically related to the two errors mentioned above, and which focused more upon drivers' opinions about certain driving practices at junctions. However, the second series of items was designed specifically to relate to these errors, and respondents were asked to report how much each one reflected their own driving style. This division was done mainly because the whole section was judged to be too long, and it was thought that this division provided a logical break in the flow of the questionnaire.

It was decided that the most appropriate scale for this series of questions was a Likert scale in which the respondent is presented with a statement and then asked to state the extent to which s/he agrees with that statement. Such scales are generally labelled: 'strongly agree', 'agree', 'uncertain', 'disagree' and 'strongly disagree'. The advantage of using this kind of scale is that the categories have "unambiguous ordinality" (Babbie, 1973). In other words, there can be no doubting that there is a specific order inherent in the scale.

7.4.6 Section 7: Scenarios and Increased Likelihood of Accident-Involvement Items

As outlined in Chapter 6, one of the aims of the questionnaire study was to determine the ways in which drivers make judgements about driving at junctions. Researchers have often used scenarios to determine the levels of particular variables at which changes in behaviour become apparent. For example, Mannering, Bottiger and Black (1987) altered the levels of four variables (location, time of day, distance from home and number of drinks in the last hour) in a questionnaire-administered scenario to determine the situations in which subjects make the decision whether or not to drive after drinking. Perhaps even more relevant to the current research are the scenarios used by Harris (1987) in his study of overtaking behaviour in which the levels of such factors as junction layout and sight distance were varied.

It was intended that the questionnaire would contain scenarios of this nature in which variables such as approach speed, following distances, speeds of other vehicles and density of traffic were subjected to differing levels to determine the important levels of variables implicated in the two main activities under study: close-following and failing to 'give way' when necessary. However, after experimenting with many different versions, it was decided that the scenario format was too static and that there were too many assumptions implicated in their use in this case. For example, without extremely explicit diagrams, one can never be certain that all respondents have understood the scenario in the manner intended by the researcher. In addition, for this particular purpose, many variables would have to be manipulated in each situation, and a fully-controlled series of scenarios would constitute a study in their own right. The accident details and opinion items were considered to be of greater importance to the overall objectives of this research and therefore less expendable than the scenarios.

However, it was felt that some more basic scenario-type items relating to these situations could be included. Therefore, one 'scenario' for each of the three main accident-categories, rear-end-shunt, left-turn and cross-traffic collisions, was included. The scenarios sections included items such as the number of times the respondent has been involved in such incidents in the previous twelve months, as well as originally asking for the respondents' perceived probability of each manoeuvre resulting in both an accident and a near-miss. As an alternative to using variable scenarios to discover the factors that are important in the situations described in this section, the respondents could be asked directly about the circumstances under which they feel that they would be more likely to be involved in an accident. Hence for each of the three situations described, respondents were initially asked to list three circumstances under which they would be more likely to be involved in an accident. The most commonly-suggested items from this open-ended format were then included as closed questions for the main survey, using Likert scales as described in the previous section.

An additional two questions were included at the end of the questionnaire as it was felt that they may be somewhat contentious and that an earlier placing may have reduced the number of completed questionnaires returned. Respondents were asked to rate the probability of both themselves and an 'average' driver becoming involved in a road accident during the subsequent twelve month period. Previous research has compared young and older drivers' responses when asked to rate their probability of being involved in an accident, but the results have been somewhat contradictory. For example, Jonah and Dawson (1982) found that younger drivers tended to rate (using a logarithmic scale) themselves as being more likely to be involved in an accident during the next twelve months, whilst Finn and Bragg (1986) reported the opposite phenomenon. Despite these apparent contradictions, it was felt that a similar comparison between specific sub-groups may be highly revealing.

Having outlined the main items included within the questionnaire, the following section briefly describes the several stages of pre-testing and piloting that preceded the main survey, before detailing the procedure adopted for that main survey.

7.5: PRE-TEST & PILOT STAGES

7.5.1 Rationale for the Pre-Test Stage

Once a draft copy of the questionnaire had been produced, it had to be evaluated by pre-testing on a small number of subjects to highlight any shortcomings in the design such as logical errors, ambiguity in item phrasing, and grammatical mistakes. The use of a pre-test stage should be distinguished from the pilot stage and its' usefulness should not be under-estimated. It is clearly preferable to identify difficulties at an early stage so that sufficient time is available to complete a full pilot survey from which only minor changes need be made to the final version of the questionnaire.

As the purpose of this stage of the survey was to identify any problems with the questionnaire itself, it was decided that the pre-test subjects did not necessarily have to be representative of the target population, nor did the administration of the questionnaire need to be carried out in the same fashion as the main survey. Hence, copies of the first draft of the questionnaire were distributed to twenty-seven colleagues in the Applied Psychology Unit at Cranfield Institute of Technology for self-completion purposes. Although most of the subjects could drive, the few who had not passed their driving test were asked to pass the questionnaire on to someone who had. The second pre-test survey was distributed to a small number (30) of students of the MBA course at the School of Management at Cranfield.

7.5.2 Assessment of the Pre-Test Surveys and Details of Resulting Alterations Made to the Questionnaire

From the first pre-test survey, seventeen completed questionnaires (63%) were returned within a few days. At this stage, most sections were answered with apparently few problems. However, as noted in Section 7.4.3, many respondents had difficulties with the logarithmic probability scales used for several items, and therefore these were altered as previously noted. In addition, the changes outlined in Section 7.4.4 concerning drivers' self-descriptions were changed as a result of this pre-test.

The second pre-test survey was performed as a result of the major changes that were made to the questionnaire on the basis of the previous pre-test. Unfortunately, due to the timing of this survey, very few completed questionnaires were returned in the period immediately after distribution, although after a period of around four weeks, 12 (40%) of the respondents had returned their questionnaire. This can not be considered to be a particularly impressive return rate under the circumstances, but it should be stressed that the sample was not representative of the intended population, and it is to be hoped that this intended population have more available time in which to complete the questionnaire.

The questionnaires that were returned revealed no problems with the format, all relevant questions being answered by all respondents. However, the final section, containing the three scenarios, revealed some problems. With the use of a seven-point probability scale, rather than the logarithmic probability scale, it was felt that the scenarios too closely resembled items in the third section of the questionnaire and were therefore considered to be redundant. Rather than disposing of the scenarios altogether, it was decided that the items could still be used to determine how often the respondent had been involved in each of the incidents and hence this section was retained. In addition, the respondents completed the open-ended items for each of the scenarios in almost exclusively identical ways, indicating that the named circumstance(s) would make them more likely to be involved in an accident at a junction, regardless of the specific manoeuvre being undertaken. It was therefore decided to combine these three sub-sections and merely ask respondents to rate circumstances which would make them more likely to become involved in an accident at a junction in general. The open-end format was also changed in favour of a number of closed items drawn from the most frequently suggested responses in the pre-test.

7.5.3 The Pilot Survey

For the purposes of the pilot survey, a sample size of around 100 was chosen, consisting of 30 accident-involved drivers from the police sample and 70 from the general sample. However, at the time that the pilot survey was to be carried out, the latter sample still had not been received and, rather than waste valuable time in waiting for the names and addresses, it was decided to find an alternative source for the pilot survey that would be representative of the intended sample. Perhaps the most readily available source of names and addresses are telephone directories, and it was felt that a random sample from the full set for this country would be a good substitute for the general driver sample. However, the main difference between these two samples is that not everyone listed in the telephone books holds a full driving licence as required by the survey. It was therefore felt that some degree of over-sampling was needed, and an assumed hit-rate (ie. people from this sample with full driving licences) of 50% was adopted - a figure that may be under-optimistic, but nevertheless sufficient for the purposes of the pilot survey. In line with the main survey, a proportion of these names and addresses were selected from the Milton Keynes area, the remainder from directories for the rest of the country. Rough calculations, based upon the sample size required and the number of directories available, meant that three names and addresses (one from each of the front end, the middle and the rear end of the book) were selected from

from every third telephone book in the order that they were stacked on the shelves of Bedford library. In total, 140 names and addresses for use in the pilot survey were obtained in this fashion.

An additional feature of the questionnaire introduced at this stage was the inclusion of an incentive to boost the return rates. This took the form of a free draw which required the respondent to fill in a small form to be returned with the questionnaire, offering three levels of prizes (£20, £10 and £5) along with a choice as to the form of the prize (book token, record token, or a Halfords gift voucher). A similar survey by Harris (1987) utilised this technique, and produced a return rate of around 36.2% without the use of reminder letters.

7.5.4 Procedure for the Pilot Stage

The procedure for the pilot survey was identical to that adopted for the main survey, which is described in Section 7.6.

7.5.5 Response to the Pilot Survey and Alterations Made to the Questionnaire as a Result

A total of 46 questionnaires (27.1%) were returned, including 13 from the accident-involved sample (36.1%). The low return rate from the telephone directories samples was perhaps to be expected for the reasons outlined in Section 7.5.3, and it may be considered that, under the circumstances, a return rate of 23.6% from this sample is reasonably good.

Once again, the questionnaire revealed no substantial problems. In addition to a few grammatical errors and one incorrect page throw, the only difficulty concerned a couple of items in Section 5 (containing opinions about driving at junctions) which revealed virtually no variance. These items, including ones concerned with signalling behaviour and responses to the presence of a queue waiting to enter a junction, would have been useless for the analyses, and so it was decided to replace them with additional items derived from the discussion groups for which there had been insufficient space previously. However, this change of format meant that an additional pilot survey was necessary to assess the suitability of the additional items.

7.5.6 Second Pilot Survey

The main purpose of this additional survey was purely to assess the suitability of a small number of new items, and therefore it was not felt that a sample that was representative of that to be used for the main survey need be used. Rather than utilise yet more of the accident-involved sample, and also as the general sample had still not been obtained, it was decided to adopt the 'telephone directory' approach once again for this second pilot survey. Questionnaires were sent to 100 people randomly selected from the Bedford telephone directory, the procedure again identical to that used in the main survey described in Section 7.6.

In total, 36 questionnaires (36%) were returned, a rather surprisingly high number considering the nature of the pilot. No problems were reported with the new format, and all relevant sections were again completed by all respondents. It was therefore decided that no further changes need be made for the main survey. A copy of the final version of the questionnaire can be found by referring to Appendix U.

7.6: MAIN QUESTIONNAIRE SURVEY

7.6.1 Questionnaire Covering Letter

As the questionnaire was distributed by post, an introduction letter, highlighting the nature of the study and the sampling procedure, was required. The letter also included details of the free draw (outlined in Section 7.5.3), along with the detachable draw entry form, used as an incentive for recipients to return their questionnaires. However, it was felt that the accident-involved sample may be more sensitive about receiving the questionnaire, and would require some further explanation about the source of their details and the confidentiality of any information provided. Therefore, the Chief Superintendent of Thames Valley Police in Milton Keynes was approached to provide a suitable additional covering letter. A previous researcher (Brooks, 1987) had used a similar technique, and a copy of the covering letter from that study was sent as an example of the type of letter required. A copy of the letter provided by the Chief Superintendent can be found in Appendix V, and a copy of the standard covering sheet(s) sent to all potential respondents, can be found in Appendix W.

7.6.2 Procedure for the Main Questionnaire Survey

Upon receipt of the general and Milton Keynes samples, the names and addresses from all three samples were transferred onto sticky address labels and stuck onto A4 envelopes. The questionnaires for each of the samples differed slightly in that they featured a discrete numerical reference to the sample (ie. from the DVLA records or the police accident database) from which each respondent's details were originally obtained. Each envelope contained a relevant copy of the questionnaire, according to the code number, and a 'FREEPOST' A5 envelope in which the completed questionnaire could be returned.

The questionnaires were then packaged in batches of 100 to ensure that an accurate count of the total number sent out was made. They were also sent out in batches, partly for ease of transporting the questionnaires, and partly to stagger the responses so that the researcher could keep up with the coding of the returned questionnaires. The accident-involved sample were sent out approximately one week before the other samples simply due to the fact that the address labels had been prepared earlier. All questionnaires were distributed during August 1990.

7.6.3 Reminder Letters

Several weeks after the distribution of the questionnaires, it emerged that a relatively low percentage of the accident-involved sample had returned their questionnaires, and it was decided that a reminder letter may help to boost returns from this sample. Those respondents who had returned questionnaires could be identified from the draw entry forms and therefore could be excluded from this exercise. Also excluded were those potential respondents who had not received the questionnaire in the first place, either because they had changed address since their accident, or because the address was incomplete or inaccurate. A copy of the reminder letter can be found in Appendix X.

7.6.4 Treatment of Questionnaires Upon Receipt

Upon receipt, each questionnaire had its accompanying draw entry form (and covering letter, if necessary) removed so that the promise of anonymity could be maintained. A reference number was then added to each questionnaire to enable identification of individual questionnaires at any point. Although the responses to most of the questions could be read directly from the questionnaires, it was necessary to code the open-ended items prior to typing the data onto the database.

CHAPTER 8:

RESULTS FOR STUDY 2

8.0: OVERVIEW

The first section of this chapter (8.1) presents some of the basic descriptive statistics concerned with the questionnaire data, particularly concentrating on the numbers of returned questionnaires and the age and sex distributions of the respondents. One of the main purposes of the questionnaire was to gain some detailed information about accidents at junctions, and therefore Section 8.2 presents accident-related descriptive statistics, providing breakdowns of many of the closed and open-ended items concerned with accident avoidance and prevention. In addition, the issue of accident culpability is dealt with, comparing respondents' attributions of culpability with those of a group of independent raters.

Each of the main sections of the questionnaire, barring those dealing with descriptive items, was subjected to a principal components analysis in a bid to uncover any underlying structures within the items in each of those sections. Section 8.3 provides summarized details of these analyses, as well as describing the reliability assessments performed on each of the scales compiled as a direct result of the principal components analyses. The metavariables derived from the PCAs were then used as predictor variables in a series of multiple regression and discriminant function analyses. In Section 8.4, an analysis in which they were used to predict levels of accident involvement is described. This is followed by an additional analysis using basically the same set of predictors to investigate junction-accident involvement. However, it was felt that a more pertinent analysis would be one that discriminated between culpable and non-culpable junction accident-involved drivers, and this analysis is outlined in Section 8.5, along with an additional DFA designed to discriminate between respondents who admitted their culpability and those who denied it. Section 8.6 is concerned with respondents' perceptions of their control over prevention of the accident, and the relationship of this measure of helplessness to admission of culpability is briefly touched upon.

The main accident types discovered during the observation study were used as the basis for the analyses described in Section 8.7. One metavariable was found to be a particularly good predictor of accident liability and Section 8.8 describes a multiple regression analysis performed to uncover demographic characteristics possessed by drivers scoring highly on this self-descriptor metavariable. The final major section of this chapter (8.9) concentrates upon issues concerned with driver training, whilst the main points from this chapter are summarized in Section 8.10. All analyses were performed using $SPSS^x$ on a VAX-11/750 VMS V4.5. In addition, a list of variable names used in the questionnaire study can be found in Appendix Y.

8.1: DESCRIPTIVE STATISTICS - GENERAL DETAILS

8.1.1 Number of Questionnaires Returned

Table 8.1 (below) shows the number (and percentages in parentheses) of questionnaires returned in a useable format from each of the three samples: those from all registered drivers in the UK; those from registered drivers in the Milton Keynes area; and those from the Thames Valley Police accident records. Also shown in the table are the number and percentage of questionnaires that were returned uncompleted (for whatever reason) and those that could not be delivered to the intended respondent and therefore returned. Finally, in order to present a more accurate impression of the true proportion of questionnaires returned, those that were returned as undelivered or returned uncompleted were subtracted from the total number distributed. The number of completed and usable questionnaires returned could then be expressed as a function of this figure, as shown in the final row of Table 8.1.

Table 8.1: Number and Proportion of Questionnaires Returned from each Sample

	Sample:			
Number of Questionnaires:	General (GEN)	Milton Keynes (MK)	Police Accident Records (PAR)	TOTAL
Returned Completed	405 (27.0)	176 (35.2)	159 (22.7)	740 (27.4)
Returned Uncompleted	9 (0.6)	2 (0.4)	2 (0.3)	13 (0.5)
Returned Undelivered	105 (7.0)	18 (3.6)	32 (4.6)	155 (5.7)
Unreturned	981 (65.4)	304 (60.8)	507 (72.4)	1792 (66.4)
True Proportion of Questionnaires Returned	29.2	36.7	23.9	29.2
TOTAL	1500	500	700	2700

Table 8.1 reveals that the overall return rate was just under 30% (29.2), with the Milton Keynes sample (herein referred to as the MK sample) producing the best rate (36.7%) and the Police Accident Records (PAR) sample producing the lowest (23.9). A relatively high proportion (6.2%) of questionnaires from the TRRL sample (ie. the

'General' (GEN) and MK samples combined) were not delivered to the addressee, suggesting that the database was not as accurate or current as anticipated.

8.1.2 Age and Sex Distributions

It was felt that it would be pertinent to assess the representativeness of the received sample in order that any inferences made during this study can be directed at the correct target group. The only meaningful method of doing this with the available data was to compare the age and sex distributions of the sample with that of the total UK driving population. Therefore, the DVLA were contacted and a current copy of this information was obtained. Table 8.2 (below and over) shows the number of respondents falling into each age and sex category (as defined by the DVLA) received in each sample along with the corresponding figures for the UK population as of April 1990 (the most recent figures available). The percentages for each sample, including the UK population, are shown in parentheses.

Table 8.2: Age and Sex Distribution of Respondents in each Sample in Comparison to UK Driving Population

Age & Sex Category:		Sample: GEN	MK	PAR	TOTAL	UK Driving Population
16-25	M	32 (8.0)	11 (6.4)	21 (13.3)	64 (8.7)	2535585 (8.8)
	F	35 (8.7)	18 (10.4)	12 (7.6)	65 (8.9)	1862526 (6.5)
26-30	M	29 (7.2)	7 (4.0)	17 (10.8)	53 (7.2)	1911775 (6.7)
	F	20 (5.0)	15 (8.7)	9 (5.7)	44 (6.0)	1441325 (5.0)
31-40	M	54 (13.5)	19 (11.0)	22 (13.9)	95 (13.0)	3548492 (12.4)
	F	47 (11.7)	23 (13.3)	13 (8.2)	83 (11.3)	2666918 (9.3)
41-50	M	44 (11.0)	21 (12.1)	17 (10.8)	82 (11.2)	3409369 (11.9)
	F	31 (7.7)	20 (11.6)	12 (7.6)	63 (8.6)	2352315 (8.2)

(cont. over)

Table 8.2: Age and Sex Distribution of Respondents in each Sample in Comparison to UK Driving Population (cont.)

Age & Sex Category:		Sample: GEN	MK	PAR	TOTAL	UK Driving Population
51-60	M	39 (9.7)	15 (8.7)	16 (10.1)	70 (9.6)	2671496 (9.3)
	F	15 (3.7)	6 (3.5)	3 (1.9)	24 (3.3)	1467265 (5.1)
61-70	M	29 (7.2)	11 (6.4)	8 (5.1)	48 (6.6)	2357295 (8.2)
	F	10 (2.5)	2 (1.2)	3 (1.9)	15 (2.0)	994737 (3.5)
71+	M	11 (2.7)	3 (1.7)	4 (2.5)	18 (2.5)	1090291 (3.8)
	F	5 (1.2)	2 (1.2)	1 (0.6)	8 (1.1)	405679 (1.4)
Total	M	238 (59.4)	87 (50.3)	105 (66.5)	430 (58.7)	17524303 (61.0)
	F	163 (40.6)	86 (49.7)	53 (33.5)	302 (41.3)	11190765 (39.0)
OVERALL TOTAL		401	173	158	732	28715068

One of the most notable aspects of Table 8.2 is the high proportion of female respondents, particularly in the younger age categories, for whom the sample proportion exceeds the population proportion for all age categories up to (and including) the 41-50 range. However, a chi-square analysis performed on the sex distributions produced a chi-square value of 1.70 (df=1, with Yates' correction) which is not significant at the 5% level, and so the hypothesis that the proportion of respondents in the sample and the population are distributed in an equivalent manner is accepted. A further chi-square analysis in which the age categories were also considered was performed, comparing the distribution of respondents in each age category obtained in the whole sample to that of the population. The analysis produced a chi-square value of 17.55 (df=6), found to be significant at the 1% level (a value of 16.81 being sufficient for significance at this level). In other words, the hypothesis that the age distribution of the received sample is equivalent to the distribution in the population must be rejected.

However, it was felt that some demographic characteristics of the PAR sample may have caused certain categories to be over-represented in the sample. For example, Table 8.2 reveals that responses were received from many more younger male drivers in the PAR sample than the population figures suggest. Therefore, an additional chi-square analysis was performed, comparing the combined GEN and MK samples with the population figures. In this case, the calculated value of chi-square was 10.55 with 6 df, not significant at the 0.05 level (a value of 12.59 being required). Therefore, it can be concluded that the sample obtained from the DVLA database of current British drivers was representative, in terms of the age distribution, with the known population of those drivers.

8.1.3 Other Demographic and General Driving Details

In this introductory section, it would be useful to look briefly at some of the responses to the more relevant demographic items contained in the first section of the questionnaire. Table 8.3 (below) shows the number (and proportion) of respondents in each sample who reported holding a full car driving licence, driving a car more than any other vehicle, and driving as part of their work.

Table 8.3: Summary of Responses to Categorical Demographic Variables for each Sample

	Sample:			
	GEN	MK	PAR	TOTAL
Number of car licence holders	398 (98.8)	172 (97.7)	151 (96.2)	721 (98.0)
Main vehicle driven - car	378 (93.3)	168 (95.5)	138 (86.8)	684 (92.4)
Number of respondents who drive as part of work	166 (41.5)	63 (40.1)	83 (58.0)	312 (47.8)

An interesting aspect of this table is the proportion of respondents in the PAR sample (in theory all accident-involved) who reported driving as part of their work (58.0% compared with around 40% in the other samples). Indeed, the distribution of such respondents was found to significantly differ at the 1% level (chi-squared=9.80 with 2 degrees of freedom, p=0.007). Respondents from this sample also differed from the others in their responses to the other two items listed here. Marginally fewer claimed to be full car driving licence holders, a result found to be non-significant (chi-squared=3.83 with 2 deg. free., p=0.147). However, a significantly lower proportion of PAR respondents claimed to drive a car primarily (chi-squared=10.00 with 2 deg. free., p=0.007).

In a similar way, Table 8.4 (below) shows the means, standard deviations and sample sizes (N) for some of the variables recording data of a non-categorical nature in the opening section of the questionnaire for all three samples. Full details of the descriptive statistics for all non-categorical variables can be found in Appendix Z.

Table 8.4: **Summary of Responses to Demographic Variables of Continuous Nature for each Sample**

	Sample:			
	GEN	MK	PAR	TOTAL
Mean number of driving lessons	14.98 (11.08) (381)	16.51 (14.96) (164)	17.43 (13.79) (145)	15.86 (12.71) (690)
Mean number of years driving on regular basis	18.45 (13.11) (400)	17.65 (12.24) (176)	16.25 (12.50) (154)	17.79 (12.79) (730)
Mean number of times car driving test taken	1.56 (0.80) (391)	1.58 (0.97) (170)	1.74 (0.95) (147)	1.60 (0.87) (708)
Mean number of miles driven per year (x 1000)	11.67 (11.08) (398)	12.53 (13.39) (174)	20.58 (20.45) (153)	13.76 (14.51) (725)

Respondents from the PAR sample are distinguishable from those in the two remaining samples in that they reported taking the driving test more times than respondents in the other two samples, and claimed to drive considerably more miles per year on average than those from the other samples. On the other two variables reported here, respondents from the GEN sample received fewer driving lessons from a qualified instructor and had been driving regularly for more years on average than respondents from the other samples.

Analyses of variance were performed on each of the variables listed in Table 8.4, although only the annual mileage of drivers significantly differed between the three samples ($F_{(2,722)}=22.92$, $p=<0.001$). A Newman-Keuls test performed on the means revealed that the annual mileage of the PAR sample significantly differed (at the 1% level) from that of drivers in the other two samples, whilst these latter two groups of drivers were not found to have significantly different annual mileages. The remaining analyses: the number of driving lessons taken ($F_{(2,687)}$=2.26, p=0.105); the driving experience of respondents ($F_{(2,727)}$=1.66, p=0.191); and the number of occasions on which the driving test was taken ($F_{(2,705)}$=2.20, p=0.111) all produced non-significant results.

8.1.4 Summary of Section 8.1

The proportion of returned questionnaires was quite low, with only 29.2% of those delivered returned containing useable data. The basic demographic (ie. age and sex) distribution of respondents was not found to be significantly different from that of the known driving population, although there were slightly more responses from females than anticipated, particularly in younger age categories. In response to other basic descriptive items, the PAR sample was found to produce the most diverse responses, with fewer of these drivers having full car driving licences, fewer using a car as their first vehicle and more driving as part of their work. These drivers were found to have a tendency to report a significantly higher annual mileage, although they were also found to report having taken more driving lessons and driving tests than other drivers.

8.2: DESCRIPTIVE STATISTICS - ACCIDENT DETAILS

8.2.1 General Accident Details for each Sample

Table 8.5 (below) lists the number of respondents from each of the three samples who reported having at least one accident at any location. Also included are the number of respondents involved in at least one accident at a junction and the number of these accidents for which they considered themselves the responsible party. The table concludes with the mean number of accidents the respondents in each sample reported being involved in. The figures in brackets are the percentages of all drivers in each sample to report the information.

Table 8.5: General Accident Details for each Sample

	Sample:			
	GEN	MK	PAR	TOTAL
Number of respondents involved in at least one accident	153 (37.8)	90 (51.1)	140 (88.1)	383 (51.8)
Number of respondents involved in at least one accident at a junction	100 (24.8)	53 (30.1)	136 (86.1)	289 (39.1)
Number of respondents responsible for at least one accident at a junction	43 (10.6)	19 (10.7)	81 (50.9)	143 (19.3)
Mean number of accidents respondents involved in	0.71 (1.20) (405)	0.85 (1.17) (176)	1.58 (1.38) (159)	0.93 (1.28) (740)

Not surprisingly, the PAR sample produced the highest proportion of all accident types reported in the table. However, it is surprising that only 86.1% of the PAR sample reported being involved in an accident at a junction when it is considered that respondents were included in this sample purely on the basis of their involvement in a junction accident. Drivers in the MK sample also reported a higher accident rate than their UK counterparts for all accidents and junction accidents, although the GEN sample produced a proportion of respondents claiming responsibility for at least one of those junction accidents equivalent to the MK sample. The overall mean number of accidents of all types was notably higher for the PAR respondents, with the GEN respondents producing the smallest number of accidents-per-driver.

8.2.2 Classification of Accidents Types

The questionnaire included a section which allowed the respondent to provide a brief summary of the most recent accident they had been involved in. Although some of the responses were of poor descriptive quality, the majority could be classified in one of a relatively small number of ways. Table 8.6 (below and over) summarises the main accident classes reported by respondents, along with the number of reported accidents falling into each category. Full details, including a description of each accident type, are given in Appendix AA.

Table 8.6: Main Accident Categories - Summarized

	Number of Reported Accidents:			
Accident Type:	GEN	MK	PAR	TOTAL
Left-turn	4 (2.6)	3 (3.3)	14 (10.0)	21 (5.5)
Rear-end shunt	24 (15.7)	14 (15.6)	34 (24.3)	72 (18.8)
Cross-traffic	9 (5.9)	5 (5.6)	29 (20.7)	43 (11.2)
Right-turn	2 (1.3)	0 (-)	0 (-)	2 (0.5)
Loss of control/Skid	7 (4.6)	4 (4.4)	6 (4.3)	17 (4.4)
Overtaking manoeuvre	1 (0.7)	0 (-)	2 (1.4)	3 (0.8)
Strayed onto wrong carriageway	6 (3.9)	6 (6.7)	0 (-)	12 (3.1)
Hit obstruction	10 (6.5)	4 (4.4)	7 (5.0)	21 (5.5)
Cut across path of other vehicle	1 (0.7)	1 (1.1)	1 (0.7)	3 (0.8)
Collision whilst parking	3 (2.0)	2 (2.2)	0 (-)	5 (1.3)

(cont. over)

Table 8.6: Main Accident Categories - Summarized (cont.)

Accident Type:	GEN	MK	PAR	TOTAL
	Number of Reported Accidents:			
Hit by other vehicle	72 (47.1)	45 (50.0)	20 (14.3)	137 (35.8)
Insufficient information	14 (9.2)	6 (6.7)	27 (19.3)	47 (12.3)
TOTAL	153	90	140	383

Other than those accidents for which there was insufficient evidence for classification, the table reveals that the single most common category (accounting for over a third of the cases - 36.1%) was that in which the accident describer was the 'victim' of the accident, being hit by another vehicle. Almost a fifth (18.8%) of the accidents were of the rear-end shunt variety in which the respondent ran into the vehicle in front. Another common form of accident is that in which the respondent pulled out into the path of another vehicle, here represented by four categories: left-turn (5.5%); cross-traffic (11.2%); right-turn (0.5%); and cutting across path of another vehicle (0.8%), giving a total of 18.0% when combined. The only other class of accident which accounted for more than 5% of all cases were those in which the reporter hit an obstruction, accounting for 5.5% of the 383 accidents. It is interesting to note that, whilst the GEN and MK samples showed very similar accident distributions, the PAR sample differed quite substantially. More examples of rear-end shunt, cross-traffic and left-turn accidents were reported by drivers in this sample, whilst also recording far fewer 'hit by other vehicle' incidents. Finally, it is of interest that a higher proportion of these PAR respondents provided insufficient information for classification to be made.

8.2.3 Accident Descriptive Details: Locations of Accidents

As this research aimed to focus upon accidents occurring at junctions, it was necessary to ask respondents to classify the location of the described accident. Table 8.7 (over) summarises the number of accidents occurring at each of a number of types of road location. Full details of the locations are given in Appendix AA.

This table clearly shows that just over a quarter (25.1%) of all the accidents described did not occur at junctions, as requested if the respondent had not been involved in a junction accident. The most common accident site was the T-junction, accounting for over a third (35.0%) of cases, with over 20% occurring at roundabouts. The main differences between the samples are the higher proportion of PAR drivers reporting accidents at junctions (not surprising considering the selection procedure for these respondents) and the lower proportion of GEN drivers reporting accidents at roundabouts. It should be noted that the total number of junction accidents on the basis of this table is given as 287, whereas the figure given in Table 8.5 is 289. The latter figure is the true value, the discrepancy in this table presumably being due to some respondents' insufficient understanding of what constitutes a junction.

Table 8.7: Locations of Accidents

	Number of Reported Accidents:			
Location:	GEN	MK	PAR	TOTAL
Not at/near junction	50 (32.7)	30 (33.3)	16 (11.4)	96 (25.1)
Roundabout	16 (10.5)	22 (24.4)	41 (29.3)	79 (20.6)
T-junction	55 (35.9)	20 (22.2)	59 (42.1)	134 (35.0)
Crossroads	22 (14.4)	9 (10.0)	12 (8.6)	43 (11.2)
Other type of junction	10 (6.5)	5 (5.6)	12 (8.6)	27 (7.0)
Unknown	0 (-)	4 (4.4)	0 (-)	4 (1.0)
TOTAL	153	90	140	383

8.2.4 Accident Descriptive Details: Vehicle Types Involved in Accidents

It was also felt to be of interest to have a brief look at the types of vehicles accident-involved respondents were driving at the time of their accidents. Table 8.8 (over) lists the number and proportion of each type of vehicle involved in the described accidents for each sample. Furthermore, Section AA.2 in Appendix AA lists the numbers of each type of road user also reported to be involved in these accidents.

Table 8.8: Vehicle Types Involved in Accidents

Vehicle Class:	Number of Reported Accidents: GEN	MK	PAR	TOTAL
Car	141 (92.2)	81 (90.0)	117 (83.6)	339 (88.5)
Motorcycle	4 (2.6)	0 (-)	6 (4.3)	10 (2.6)
Light goods vehicle	4 (2.6)	3 (3.3)	7 (5.0)	14 (3.7)
Heavy goods vehicle	3 (2.0)	2 (2.2)	7 (5.0)	12 (3.1)
Bus/coach	0 (-)	0 (-)	3 (2.1)	3 (0.8)
Car with trailer	1 (0.7)	0 (-)	0 (-)	1 (0.3)
Unspecified	0 (-)	4 (4.4)	0 (-)	4 (1.0)
TOTAL	153	90	140	383

The table reveals that the vast majority (88.5%) of respondents were driving cars at the time of the accidents. Light goods vehicles, heavy goods vehicle and motorcycles had a small number of representatives, each accounting for around 3% of the total. It is notable that relatively fewer drivers from the PAR sample were car drivers, whilst a higher proportion were driving light goods, heavy goods and public service vehicles at the time of the accident. From Section AA.2 it can be seen that cars did not feature quite so extensively as the other road user type involved in the accidents, with just under 70% (69.7) of the accidents involving at least one other car and one accident involving four other cars. Once again, light goods vehicles, heavy goods vehicles and motorcyclists were involved in several accidents (each involved in between 5 and 10% of the accidents). However, cyclists were more highly represented than expected, with 12 (3.1%) of the accidents also featuring this type of road user.

8.2.5 Accident Avoidance Measures

In addition to providing a description of the accident, respondents were also asked which avoidance measures, if any, they adopted in an effort to prevent a collision. A maximum of two were coded from the questionnaire (the first two being used if more than two tactics were proffered) and Table 8.9 (below) summarises the main categories of avoidance procedure adopted by accident-involved respondents along with the number, and proportion, of drivers utilising each one. Respondents were also asked to state their reasons for adopting those particular avoidance methods, and Table 8.10 (over) summarises the accompanying reasons for the adoption of these measures cited by the respondents. At this point, it was no longer considered relevant to discriminate on the basis of sample, and therefore the following tables contain cases from all samples combined. It should be noted that, as a combination of avoidance measures and reasons for their adoption could be suggested by each respondent, the final columns in Tables 8.9 and 8.10 do not sum to 100%. The complete lists for both sections can be found in Appendix AA.

Table 8.9: **Main Accident Avoidance Procedures Employed**

Avoidance Procedure:	Frequency of citation	Valid %
None adopted	162	42.3
Braking	137	35.8
Swerving	73	19.1
Stopping	28	7.3
Accelerating	8	2.1
Turning into skid	5	1.3
Other	7	1.8
Not specified	6	1.6

Table 8.9 reveals that a relatively high proportion (42.3%) of the accident-involved drivers did not adopt any form of avoidance measure prior to the collision. By far the most common form of avoidance tactic was braking, adopted by over a third (35.8%) of the respondents to this item. The only other form of avoidance measure to account for over 10% of cases was the 'swerve' manoeuvre (19.1%).

Table 8.10: Major Reasons for Adoption of Avoidance Procedures

Reason for adoption of avoidance tactic:	Frequency of citation	Valid %
Best/only option available	95	45.2
Automatic response	44	21.0
Panic/lack of control	3	1.4
Result of training	2	1.0
To avoid/minimise impact of collision	45	21.4
Create space	5	2.4
Other	16	7.6

The reasons for the adoption of these measures listed in Table 8.10 show that by most common class of reason was that covering the 'most applicable option' answers, a response supplied by almost half (45.2%) of the accident-involved drivers who adopted some form of avoidance measure. Over a fifth (21.0%) of respondents felt that their choice of collision-avoidance manoeuvre was an automatic response, whilst a similar proportion (21.4%) provided the non-explanatory 'impact avoidance' type of response.

8.2.6 Accident Prevention Measures for Self and Others

Accident-involved drivers were also asked to suggest ways in which the accident described could have been prevented, both personally and for any other person or organisation. Table 8.11 (over) lists the summarized accident prevention measures respondents suggested both for themselves and for another party also involved in some way. The table lists the frequency of occurrence of each category along with the relevant percentage in brackets. The complete categories for both sections can be found in Appendix AA. In line with the previous two tables, the final column of percentages do not total to 100 as each respondent could supply two prevention measures for themselves and for another party.

Table 8.11: **Accident Prevention Measures for Self and Others**

	Frequency & Percentage of use			
	Self		Other	
	Freq.	Valid %	Freq.	Valid %
Nothing	219	57.2	115	30.0
Not performed manoeuvre	11	2.9	26	6.8
Driven more slowly	24	6.3	58	15.1
Been more observant/careful	77	20.1	86	22.5
Been more decisive	6	1.6	18	4.7
Junction altered by authorities	0	0.0	38	9.9
Waited/hesitated	28	7.3	25	6.5
Signalled intentions/been more visible	1	0.3	12	3.1
Adopted better road position	10	2.6	12	3.1
Driver should not have been unfit to drive (inc. drink-driving)	2	0.5	4	1.0
Swerved	1	0.3	2	0.5
Remained calm	3	0.8	0	0.0
Other	9	2.3	12	3.1
Not specified	14	3.7	16	4.2

The comparisons between responses for the accident describer and the other party show some very revealing differences. For example, well over half (57.2%) of the respondents felt that there had been nothing they could have done to prevent the collision, whilst they felt that another party was similarly unable to help the situation in only 30% of cases. For the vast majority of the prevention categories, the other party was cited as being able to prevent the accident by respondents more often than they cited themselves. The only exceptions to this were the 'waited/hesitated' (7.3 and 6.5% for self and other respectively) and the 'remained calm' (0.8 and 0.0% respectively) categories.

8.2.7 Accident Attributions

The twelve categories of accident contribution factors (Question 27) were included so as to ascertain the relative contribution the respondent felt each made to the accident in question. Table 8.12 (below and over) summarises the responses to the most commonly used items, showing the proportion of respondents who felt that the accident described was mainly (a combination of the 'totally' and 'considerably' categories), somewhat (a combination of 'moderately' and 'minimally') or not at all due to each of the main items. The actual mean scores for the full set of items may be found in Appendix Z. The figures in brackets are the valid percentages.

Table 8.12: Respondents' Accident Attributions

Item:	Attribution:		
	Mainly	Somewhat	Not at all
Own Driving	102 (27.2)	130 (34.7)	143 (38.1)
Other's Driving	217 (59.6)	78 (21.4)	69 (19.0)
A Non-Driving Road User	18 (5.5)	6 (1.8)	306 (92.7)
Road/Weather	69 (19.5)	70 (19.7)	216 (60.8)
Poor Visibility	63 (18.2)	38 (11.0)	245 (70.8)
Excessive Speed on Own Part	13 (3.8)	65 (18.5)	272 (77.7)
Impatience on Own Part	20 (5.7)	72 (20.6)	258 (73.7)
Own Lack of Concentration	80 (22.1)	94 (26.0)	188 (51.9)

(cont. over)

Table 8.12: Respondents' Accident Attributions (cont.)

Item:	Attribution: Mainly	Somewhat	Not at all
Poor Road Design	80 (22.7)	79 (22.4)	193 (54.8)
Own Poor Judgement of other Vehicle	98 (27.3)	83 (23.1)	178 (49.6)
Mechanical Failure	10 (2.9)	7 (2.0)	331 (95.1)
Fatigue on Own Part	16 (4.6)	40 (11.6)	290 (83.8)

In accordance with the finding in the previous section, Table 8.12 shows that other drivers were deemed to be mainly responsible for the accident on twice as many occasions as the describer. Of the internal (to the driver) factors, lack of concentration and poor judgement of other vehicles' movements were cited the most often, both falling into the mainly responsible category on 22.1% and 27.3% of occasions respectively. Environmental factors, such as poor road design and visibility, were felt to be mainly responsible with roughly the same degree of regularity (22.7% and 18.2% respectively) but factors such as mechanical failure and excessive speed were cited on far fewer occasions (2.8% and 3.8% respectively).

Respondents were also asked to provide further factors which they felt contributed to the accident, and a full list of these factors is supplied in Appendix AA. Only 57 respondents suggested additional factors, the majority of which received single nominations. However, 'excess alcohol intake' was the most commonly-cited category, suggested by 6 respondents, with 'other driver's excess speed' suggested by 5 respondents.

8.2.8 Accident Culpability

8.2.8.1 Raters' Assessments of Culpability and Associated Reliability Tests

As it was felt that the respondent's own ratings of culpability could not be sufficiently relied upon, their accidents were assessed by three road safety researchers (including the author) in terms of culpability. Although many of the descriptions were of relatively low quality, it is felt that the majority contained sufficient information for a reliable assessment to be made, particularly when clear violations of traffic regulations and standard procedures had been made. The consistency of the ratings between the three raters, and also for one rater over three trials, were tested for reliability, the results of which can be found in Appendix BB. The raters were asked to assign one of four categories to each accident description as follows:

1 Respondent mainly or totally responsible;

2 Other driver/person/animal etc. responsible;

3 Roughly equal responsibility between respondent and other;

4 Insufficient information provided to form any opinion.

Although the level of intra-rater reliability had reached perfection by the third set of ratings, the measures of inter-rater reliability were still not sufficient to meet the demands of the study (a criterion level of 0.80 had been selected, the values of Kappa between the author and each of the other two raters being 0.63 and 0.62). However, there was agreement for the ratings of the vast majority of items (49 and 47 out of 62) between the author and the other raters and it felt that many of the disagreements may have been a result of item ambiguity rather than differences of opinions among the raters. Therefore, it was decided that, rather than repeat the rating procedure in full, the categorisation of the items for which there was not universal agreement should be individually discussed. As a result of these discussions, a consensus on all items was achieved, and the assignments of culpability used in all subsequent sections are based upon these ratings.

8.2.8.2 Comparison of Respondents' and Raters' Culpability Assessments

The main reason for performing 'expert' assessments of accident culpability was the belief that respondents would not be likely to provide impartial culpability assessments themselves, and it was felt that the former ratings would provide a more accurate assessment of true culpability than the latter. It was therefore considered to be of interest to compare the two sets of ratings, to assess the correspondence between the 'expert' and respondent ratings (obtained by subtracting the respondents' assessment of another party's guilt from that of their own guilt - see Table 8.12). Table 8.13 (over) shows the assessments of culpability made by the raters and the respondents. It should be noted that 23 cases were excluded from this table due to missing values on the self-rating scales.

Of the 326 cases for which enough information was deemed to be available by the raters, culpability assessments for 206 (63.2%) were identical for both sets of judges (raters and respondents). A relatively high proportion of respondents (57 - 17.5%) felt that they were not responsible for accidents attributed to them by the raters. Conversely, only 4 respondents (1.2%) attributed responsibility to themselves when the raters felt that another party was responsible. In being able to admit to only partial responsibility, some of the respondents (42 - 12.9%) selected this option rather than the more appropriate (according to the raters) culpable option.

Table 8.13: Accident Culpability According to Raters and Respondents

	Respondent's Assessment:			
Raters' Assessment:	Culpable	Partly Culpable	Not Culpable	TOTAL
Culpable	79	42	57	178
Partly culpable	1	0	10	11
Not culpable	4	6	127	137
Insufficient information	16	9	9	34
TOTAL	100	57	203	360

8.2.9 Summary of Section 8.2

In total, 383 accidents were described in Section 2 of the questionnaire. The respondents claimed to have been involved in a total of 688 accidents, a mean of just under one-per-respondent. Over a third of the accidents appeared to be due to another driver encroaching upon the path of the respondent's vehicle. The other most common forms of accident were those of the rear-end shunt, cross-traffic and left-turn classes. More than a quarter of the reported accidents did not occur at junctions, although 35% of them took place at T-junctions. The most common form of vehicle being driven by the respondent at the time of the described accident was the car, accounting for almost 90% of all cases. Almost a half of respondents did not report adopting any form of accident avoidance manoeuvre, the most reported form of which was braking. When asked for the reasons for adoption of the particular forms of avoidance procedure used, selection on the basis of appropriateness to the situation was the most-cited example. Over a half of the respondents felt that there was nothing they could have done to prevent the accident from occurring, although under a third of them felt that this was true of another party.

Other drivers were blamed for the accidents more often than the respondents attributed culpability to themselves. In addition to internal factors such as lack of concentration, many respondents (over a fifth) blamed environmental factors such as road and weather conditions for the accident. Finally, the reliability tests performed on the assignments of accident culpability produced satisfactory results. Almost two-thirds of respondents (63.2%) agreed with the assessment of the raters, although 17.5% felt that they were not responsible for accidents attributed to them by these raters.

8.3: PRINCIPAL COMPONENTS ANALYSES & TESTS OF RELIABILITY FOR SCALES DERIVED FROM METAVARIABLES

8.3.0 Overview

The questionnaire contained several distinct sections relating to different aspects of driving at junctions, and it was felt that it would be useful to study each of these sections individually. Of particular interest was the existence of any underlying components to each of the variable sets, hence a principal components analysis (see Section CC.1 of Appendix CC for an outline of the PCA technique) was performed on the variables contained within each distinct section of the questionnaire. It was hoped that the factors (or principal components) emerging from these analyses could then be used as independent variables in subsequent analyses. Therefore, it was felt to be important that the scales derived from these PCAs be subjected to reliability tests - in this case, Cronbach's Alpha. The PCA and reliability analyses for all five sections of the questionnaire in receipt of this treatment are summarized below, whilst the full details are presented in Appendix CC.

8.3.1 PCA and Cronbach's Alpha for Likelihood of Undesirable Driving Practices Resulting in an Accident Items

The items which measured the respondents' estimates of a number of undesirable driving practices resulting in an accident were subjected to a principal components analysis, the results of which are summarized in Table 8.14 (below). The measures of reliability are also given in Table 8.14, whilst the full details of these analyses can be found by referring to Section CC.2 in Appendix CC.

Table 8.14: Summary of PCA Analysis and Alpha Tests for Undesirable Driving Practice Items

Factor Name	Factor Label	Post-Rotation Eigenvalue	Alpha
UDPFAC1	'Carelessness/Egocentricity on approach to junction'	2.763	0.741
UDPFAC2	'Careless junction negotiation'	2.475	0.702
UDPFAC3	'Reckless driving'	2.261	0.715
UDPFAC4	'External factors'	1.918	0.657

All variables entered into the solution produced acceptable measures of sampling adequacy, as did the overall solution, and the four factors emerging from this section proved to be reasonably interpretable. The scales were produced using a unitary weighting procedure, and the table over reveals that all four achieved relatively high coefficients of reliability. It should be noted that an Alpha coefficient of 0.6 or above was considered to be sufficiently reliable for the purposes of this study (see Appendix CC).

8.3.2 PCA and Cronbach's Alpha for Self-Descriptor Items

The principal components analysis performed on the eighteen self-descriptor items is summarized in Table 8.15 (below), with the reliability coefficients for each scale also given. The results are detailed in Section CC.3 in Appendix CC.

Table 8.15: Summary of PCA Analysis and Alpha Tests for Self-Descriptor Items

Factor Name	Factor Label	Post-Rotation Eigenvalue	Alpha
DESCFAC1	'Self-centred/Ill-mannered'	4.545	0.869
DESCFAC2	'Negligent'	2.749	0.776
DESCFAC3	'Timid'	2.449	0.740

The three factors accounted for relatively large proportions of variance, with the first factor alone explaining over 25%, and all three over 54%. The value for the Kaiser-Meyer-Olkin measure of sampling adequacy (see Appendix CC) was extremely high (0.91). Certainly, the factors showed little ambiguity of interpretation, and all three scales obtained generally excellent reliability coefficients. All three scales contained one variable which would have increased the overall reliability had they been removed, but it was felt that the differences were small enough to justify inclusion of all contributing variables for the sake of completion.

8.3.3 PCA and Cronbach's Alpha for Opinion Statements

Table 8.16 (over) summarises the PCA performed on the twenty-five statements opinion statements contained in Section 5 of the questionnaire, the full details of which are contained in Section CC.4 in Appendix CC. The reliability coefficient for each scale constructed from the metavariables emerging from the PCA are also given in Table 8.16.

Table 8.16: Summary of PCA Analysis and Alpha Tests for Opinion Statements

Factor Name	Factor Label	Post-Rotation Eigenvalue	Alpha
OPINFAC1	'Inattention to vehicles on junction/Junction layout confusing'	2.602	0.621
OPINFAC2	'Special attention to vulnerable road users'	1.887	0.708
OPINFAC3	'Assertiveness at junctions'	1.812	0.488
OPINFAC4	'Conformity to others' driving style'	1.534	0.500
OPINFAC5	'Superior driving style'	1.503	0.308
OPINFAC6	'Allowing for others' errors'	1.350	-
OPINFAC7	'Safety in hands of others'	1.183	-
OPINFAC8	'Motorcyclists more cautious than others at junctions'	1.120	-

The overall solution proved to be adequate in terms of the criteria used to assess acceptability (see Appendix CC), as did each of the individual variables. Three of the eight factors contained a single variable with a factor loading score in excess of the criterion (0.45), and the last three factors are essentially equivalent to those individual variables hence reliability coefficients for these scales could not be calculated. Several factors, including the first, proved to be difficult to interpret, although others (such as OPINFAC3) were more obvious. In addition, only two of the scales produced acceptable reliability estimates, ie. in excess of 0.6.

8.3.4 PCA and Cronbach's Alpha for Reported Behaviour Items

The table over (8.17) is a summary of the PCA and reliability tests performed on the reported behaviour items from Section 6 of the questionnaire. The full details of these analyses can be found in Section CC.5 in Appendix CC.

Table 8.17: **Summary of PCA Analysis and Alpha Tests for Reported Behaviour Items**

Factor Name	Factor Label	Post-Rotation Eigenvalue	Alpha
REPOFAC1	'Inattention to vehicle in front/Impatience'	2.313	0.671
REPOFAC2	'Caution applied when approaching junctions'	1.706	0.486
REPOFAC3	'Confidence and/or caution when entering junction'	1.390	0.267

Although the overall and individual measures of sampling adequacy were within the realms of acceptability, the three factors could only explain 45.1% of the variance. The second and third factors were quite straightforward to interpret, although both showed low reliability coefficients. On the other hand, REPOFAC1 proved to be reasonably reliable but difficult to interpret, with two main themes apparent.

8.3.5 PCA and Cronbach's Alpha for Increased Probability of Accident-Involvement Items

Finally, it was decided to subject the nine items relating to increased likelihood of accident-involvement contained within Section 7 of the questionnaire to a principal components analysis. The full details of this, and the accompanying reliability tests, can be found in Section CC.6 of Appendix CC whilst the abbreviated details are presented in Table 8.18 (below).

Table 8.18: **Summary of PCA Analysis and Alpha Tests for Increased Probability of Accident-Involvement Items**

Factor Name	Factor Label	Post-Rotation Eigenvalue	Alpha
INCPFAC1	'Environmental/External factors'	2.508	0.733
INCPFAC2	'Driver/Internal factors'	2.125	0.744

The overall solution, and all individual variables, achieved acceptable measures of sampling adequacy, and the two factors outlined in the table above accounted for over 51% of the total variance. The factors proved to be highly self-explanatory and also displayed relatively high, and certainly acceptable for the purposes of this study, reliability coefficients. The removal of one variable contained within INCPFAC1 would have increased the scale's reliability marginally (from 0.733 to 0.736) but, in line with previous analyses, it was felt that the difference was too small to warrant exclusion of the variable on this basis.

8.3.6 Summary of Section 8.3

The principal components analyses described in this section all obtained acceptable levels of sampling adequacy. All solutions accounted for around 50% (ranging from 45.1% to 54.1%) of the overall variance of the individual variable sets. However, there were some differences regarding interpretability of the factors produced, with some being very obvious (eg. INCPFAC1) and others (eg. REPOFAC1) showing no single clear overall pattern. Reliability tests on the scales derived from twelve of the twenty factors (60.0%) produced coefficients that passed the criterion selected for this study.

8.4: FACTORS INFLUENCING ACCIDENT INVOLVEMENT

8.4.0 Overview

One of the main conclusions from the literature review (Chapter 1) was that the factors underlying driver behaviour was unlikely to be understood unless information gathered from different approaches (such as information processing and social interactions) were studied together rather than in isolation. The aim of the multiple regression analyses described in this section, and also the analyses described in subsequent sections, was to determine the effectiveness of the metavariables derived from various sections of the questionnaire (see Section 8.3) in predicting a variety of phenomenon concerned with accident-involvement at junctions when used in conjunction with basic descriptive information. However, it was felt that a certain degree of selectivity had to be adopted in order to avoid including meaningless metavariables and also to avoid violation of case-to-variable ratio considerations in the multivariate analyses. It is argued that the most appropriate selection criteria should therefore be based upon the reliability assessments outlined in the previous section, and for the purposes of these analyses, any metavariable producing a Cronbach's Alpha rating of 0.6 or above was deemed to sufficiently reliable to warrant inclusion.

The twelve metavariables that achieved this criterion were: UDPFAC1; UDPFAC2; UDPFAC3; UDPFAC4; DESCFAC1; DESCFAC2; DESCFAC3; OPINFAC1; OPINFAC2; REPOFAC1; INCPFAC1; INCPFAC2. In addition, sex, experience and exposure factors are often cited as being implicated in accident-involvement (eg. Brown, 1982), and it is felt that the subsequent analyses should account for these factors. Therefore, a variety of descriptive variables were included in these analyses.

8.4.1 Multiple Regression using Metavariables to Predict Accident Liability

It may be remembered from the previous chapter (Section 6.4.1) that Grayson and Maycock (1988) expressed interest in the ways in which drivers differed in their accident liability. The study performed by Harano, Peck and McBride (1975), in which a number of descriptive and psychometric performance variables were used to predict accident liability, was also cited and it is intended that this study provides the model for the analyses described in this section. Whereas Harano et. al. used mainly psychometric test scores in addition to basic descriptive information, it is felt that it would be useful to study the ability of the metavariables derived from the questionnaire to predict accident liability when this descriptive information is controlled for.

In a similar manner to Harano et. al., a stepwise multiple regression was performed to predict the total number of accidents respondents reported having been involved in during their entire driving history. It should be noted that details of all accident-involved drivers, regardless of the location of their accident, were included in the analysis. Stepwise regression differs from the standard technique in that the predictors are not all included in the solution simultaneously. Instead, each is considered in terms of its' F-ratio and only those with values above 3.84 are included. At the first step, the variable with the highest F-ratio is entered into the solution and the correlation coefficient for the remaining variables are re-calculated to account for the removal of the variable entered into the solution at the first stage. The variable with the highest re-calculated F-ratio is then entered into the solution at Step 2. The predictor entered at the first step is then re-assessed and removed if its' remaining unique contribution to the overall variance fails to reach the criterion. This process continues, by assessing predictors not yet included in the solution and the unique contributions of all previously-entered variables, until no further predictors are able to achieve the entry or removal criteria. The stepwise technique is probably the most-commonly used and is particularly useful when the predictive merit of individual variables of primary importance and it is therefore not necessary that the full set of variables are included in the final solution, as in many exploratory analyses such as those described in this chapter.

The analysis is summarized in Table 8.19 (over) and full details are presented in Section DD.1 in Appendix DD. In addition to the twelve metavariables, the following descriptive variables were included in the analysis as predictors: AGE; SEX; DRWORK (whether the respondent drives as an integral part of their work); DRSCHOOL (a re-coded variable recording whether respondents had either received most of their pre-test driving tuition from a qualified instructor or an equal mixture of an instructor and a friend or relative); FRIEND (a re-coded variable recording whether respondents had either received most of their pre-test driving tuition from a friend or relative or an equal mixture of a qualified instructor and a friend or relative); LESSONS (the number of driving school lessons received); ADTRAIN (whether the respondent has received any additional driver training); VEHICLE (the type of vehicle mainly driven - split into cars/other dichotomous variable); VEHBEL (whom the most-driven vehicle belongs to - split into self or friend or relative/employer or hire company dichotomous variable); MILES (the current annual mileage); YEARSDR (the number of years the respondent has been driving on a regular basis); TESTTIM (the number of times the car driving test was taken before qualification); TESTAGE (the respondent's age at the time of passing their driving test); MOTORWAY (the respondent's proportion of driving done on motorways); URBAN (% driving on urban roads);

RURAL (% driving on rural roads); UNFAMIL (% driving on unfamiliar roads); MOTORCYC (whether the respondent has passed the test for motorcycles); HGV (qualified HGV driver); PSV (qualified PSV driver); and PACC.

This last-named variable was calculated from the final two items on the questionnaire asking for the respondent's estimate of the probability of both themselves and the average driver being involved in an accident during the forthcoming twelve-month period. The difference between these two scores was taken (and 7 added to remove negative scores and produce a range of 1 to 13) and the resultant value is an indication of the respondent's relative assessment of their own and others' accident-involvement chances. The higher the PACC score, the more the driver believes they are immune to accident-involvement in relation to the average driver. An accurate rating, in which the respondent believes they have the same chance of accident-involvement as the average driver, would therefore be the mid-point of the scale (ie. with a value of 7).

Table 8.19: **<u>Summary of Multiple Regression using Metavariables to Predict Accident Liability</u>**

Regression Solution (N=496)	Multiple R	R^2	Adjusted R^2	F	Significance of F	Step	Variable	B	Beta
ACCS	0.437	0.191	0.178	14.358	0.000	1	SEX	0.378	0.154
						2	PACC	-0.102	-0.121
						3	VEHBEL	-0.382	-0.122
						4	YEARSDR	0.031	0.249
						5	DESCFAC1	0.032	0.162
						6	LESSONS	0.015	0.132
						7	MILES	0.012	0.143
						8	HGV	-0.582	-0.102
							(Constant)	0.176	

From Table 8.19 it can be seen that the stepwise solution produced a multiple R of over 0.4, with the value of adjusted R^2, the proportion of variance accounted for by the solution, just under 18%. The final solution produced an F-ratio of 14.36 which was found to be significant beyond the 0.1% level. The analysis produced 8 predictor variables that were able to satisfy the criteria for inclusion in the solution, with SEX being the variable with the strongest univariate relationship with ACCS, the number of accidents. With 496 cases used in the solution, the case-to-variable ratio was an acceptable 14.6:1.

In addition to the sex of the respondent, it was found that driving experience (YEARSDR) and exposure (MILES) were both effective predictors of accident liability. The signs of the regression coefficients indicate that males and those with more driving experience and higher annual mileages are likely to have been involved in a higher number of accidents. Scores on PACC were also found to be relatively good predictors, with lower scores (indicating that the respondents feel that they have more chance of accident-involvement than the average driver) being related to accident-liability. The number of driving lessons (LESSONS) received and who the most-driven vehicle belongs to (VEHBEL) were found to be related to accident liability, with those taking more lessons and mainly driving a company or hire vehicle being more likely to become accident-involved. However, it is interesting to discover that, when each of these factors is taken into account, scores on the self-descriptor DESCFAC1 were found to be relatively excellent predictors of accident-liability, with the more self-centred/ill-mannered drivers being more accident-involved. Finally, the other variable that emerged as a good predictor was HGV, indicating that those drivers who are qualified heavy goods vehicle drivers are less likely to be accident-liable.

8.4.2 Multiple Regression using Metavariables to Predict Junction Accident Involvement

One of the most basic considerations in this study concerns the differences, if any, between those drivers involved in accidents at junctions and drivers not involved in any form of accident. The analysis described in the previous section included accidents at all types of location and it was felt that it would be useful to compare the results of this analysis with those from a similar one concentrating purely upon prediction of the number of junction accidents the respondents reported being involved in. Therefore, a further stepwise multiple regression analysis was performed to predict junction-accident-liability using an identical set of predictor variables. In order to avoid the potentially confounding factor of the presence of drivers who have only been involved in accidents at locations other than junctions, these accident-involved drivers were excluded from this analysis leaving just junction accident-involved and non-accident-involved drivers. The results are summarized in Table 8.20 (over) whilst the full details are presented in Section DD.2 of Appendix DD.

Table 8.20 reveals that this MR analysis produced a very similar result to that predicting involvement in all accidents. A value of over 0.4 for multiple R was obtained and over 15% of the variance was accounted for by the solution, which retained six predictors in the final format. In addition, the case-to-variable ratio was 12.4:1, sufficient for this kind of analysis.

Table 8.20: Summary of Multiple Regression using Metavariables to Predict Junction Accident Involvement

Regression Solution: (N=423)	Multiple R	R^2	Adjusted R^2	F	Significance of F	Step	Variable	B	Beta
JUNCACCS	0.408	0.166	0.154	13.813	0.000	1	DRWORK	0.241	0.135
						2	YEARSDR	0.021	0.237
						3	DESCFAC1	0.026	0.187
						4	MILES	0.008	0.135
						5	LESSONS	0.010	0.130
						6	SEX	0.204	0.114
						(Constant)		-0.843	

The most effective predictor retained in the final solution was found to be YEARSDR, with those drivers who reported more driving experience having a greater number of accidents at junctions. Additionally, a higher number of junction accidents was shown to be linked with: more self-centred/ill-mannered self-ratings (DESCFAC1); respondents who drive as part of their work (DRWORK); a higher annual mileage (MILES); receipt of a greater number of driving lessons (LESSONS); and finally male drivers (SEX).

8.4.3 Summary of Section 8.4

In this section, the rationale behind the metavariable selection process for future multivariate analyses was outlined. The first of these analyses, a stepwise multiple regression analysis, was performed to predict general accident-involvement and the solution produced was reasonably robust. It was found that being male, having more driving experience and a greater annual exposure were the most effective predictors of increased accident-liability, although the more liable drivers were also found to describe themselves as being more self-centred and ill-mannered.

An additional multiple regression analysis which focused upon accidents at junctions proved to be almost equally successful. It was found that junction-accident-liable drivers were more likely to have driven regularly for a longer period of time, to describe themselves as more self-centred/ill-mannered to drive as part of their work and to have a higher annual mileage.

8.5: ACCIDENT CULPABILITY & ADMISSION OF CULPABILITY

8.5.1 DFA using Metavariables to Predict Junction Accident Culpability

The previous section investigated the factors implicated in accident-involvement and the analyses included all accident-involved drivers. However, it is felt that the inclusion of accident 'victims' (ie. those who were not responsible for the described accident) may have obscured one of the main issues, that of accident culpability. Therefore, a discriminant function analysis, in which those drivers deemed to be culpable for their accident were compared with the 'victims', was performed using the independent raters' assessments of culpability (see Section 8.2.6). In line with the MR analyses described in Section 8.4, this, and all subsequent, DFA analyses were performed using the stepwise variable entry procedure. This entry criterion works in a similar fashion to that used in stepwise MR. At each stage, the predictor variable with the largest F-to-enter value and smallest Wilks' Lambda value is entered into the equation. The remaining predictors are then re-evaluated for entry at the next step.

In addition to the twelve metavariables derived from the PCAs described in Section 8.3, a number of descriptive variables were also included as predictors in the analysis. However, due to case-to-variable ratio considerations, a smaller number of these variables than used in the multiple regression analyses in Section 8.4 had to be selected. The abbreviated list of descriptive variables used were: SEX; AGEACC (the respondents' ages at the time of the described accidents); DRWORK; LESSONS; ADTRAIN; ACCEXP (the respondents' driving experience at the time of the described accidents); MILES; PACC; and VEHBEL. The full details of this analysis are contained within Section DD.3 of Appendix DD, and are summarized in Table 8.21 (below).

Table 8.21: Summary of DFA using Metavariables to Predict Junction Accident Culpability

DFA Solution: (N=92)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probab-ility of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.538	0.591	34.98	0.000	65.81	1	REPOFAC1	-0.407
						2	UDPFAC1	0.395
						3	PACC	-0.357
						4	OPINFAC1	0.035
						5	MILES	-0.220
						6	ADTRAIN	0.138
						7	ACCEXP	0.058
						8	AGEACC	-0.135
						9	DESCFAC3	0.226

The table reveals that the analysis proved to be very successful, with a canonical correlation of over 0.59, accounting for just under 35% of the variance. Just over 65% of the cases were correctly classified, the probability of this occurring by chance being less than 0.001 (z=3.42) (see Section 4.5.1). It should be noted, however, that the case-to-variable ratio is very low (4.38:1) although still above the lower limit suggested by Tabachnick and Fidell (1981).

The most effective predictor variable was found to be REPOFAC1, with UDPFAC1 and PACC also emerging as good predictors. From the groups centroids (see Section DD.3 in Appendix DD) the culpable group of drivers were found to: report being worse attenders to vehicles in front and more impatient (REPOFAC1); feel that careless and egocentric junction approach styles are less likely to result in an accident at a junction (UDPFAC1); and that they are more likely than the average driver to be involved in an accident during subsequent twelve month period (PACC).

In addition, the remaining six variables that were also included in the final solution indicated that, in comparison to the non-culpable drivers, the culpable drivers reported that they: were better at attending to vehicles on a junction and do not find junction layouts confusing (OPINFAC1); have a lower annual mileage (MILES); were more likely to have received advanced tuition (ADTRAIN); had greater driving experience at the time of the accident (ACCEXP); were younger at the time of the accident (AGEACC); and are more timid (DESCFAC3).

8.5.2 DFA using Metavariables to Predict Admission/Denial of Accident Culpability

In addition to the, hopefully, more objective classification of accident-involved drivers' culpability, the respondents were given an opportunity to state their perceived degree of responsibility. The correspondence between these 'objective' and 'subjective' ratings has been dealt with in an earlier section (8.2.6), but it was felt that an additional insight into accidents at junctions may be gained by investigating the factors which discriminate between those drivers who admit and those who deny responsibility for an accident. Therefore, a further stepwise discriminant function analysis was performed using the same set of predictors as used in Section 8.5.1. However, gain as a result of case-to-variable considerations, it was necessary to reduce further the number of descriptive variables in the equation and, for this analysis, only the more basic descriptive variables (SEX, AGEACC and ACCEXP) were included. Table 8.22 (over) gives the summary statistics for this analysis, the complete details of which are presented in Section DD.4 of Appendix DD.

Table 8.22: Summary of DFA using Metavariables to Predict Admission/Denial of Accident Culpability

DFA Solution: (N=77)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.279	0.467	21.84	0.003	69.05	1	DESCFAC1	0.701
						2	REPOFAC1	-0.496
						3	ACCEXP	0.030
						4	AGEACC	-0.172
						5	UDPFAC4	0.224

This solution has a better case-to-variable ratio than the previous analysis (5.13:1) and has a relatively high canonical correlation (over 0.4) accounting for almost 22% of the variance. Additionally, the probability of correctly classifying 69.05% of cases was calculated to be less than 0.001 (z=3.49).

As with the regression analysis predicting accident liability, the most effective discriminator between culpability admitters and deniers was DESCFAC1, the deniers reporting that they were less self-centred and ill-mannered. In addition, these culpability deniers were also found to report being: better attenders to vehicles in front and more patient (REPOFAC1); less experienced at the time of the accident (ACCEXP); older at the time of the accident (AGEACC); and more likely to believe that environmental factors influence accident-involvement at junctions (UDPFAC4).

8.5.3 Summary of Section 8.5

The two discriminant function analyses described in this section aimed to uncover the factors behind accident culpability, and also admission of culpability and both analyses produced relatively good solutions. It was found that culpable drivers reported being worse attenders of vehicles in front and being more impatient, as well as feeling that careless and egocentric junction approach styles would be less likely to result in an accident at a junction. These drivers also felt that their chances of becoming involved in an accident in the immediate future was greater than that of the average driver.

When the differences between respondents who admitted responsibility for their accident and those who denied responsibility (despite being assessed as culpable by independent raters) were investigated, the main self-descriptive metavariable dominated the analysis. Those drivers classed as 'admitters' were found to be more likely to describe themselves as self-centred/ill-mannered or negligent, but also believed themselves to be worse attenders to vehicles in front and more impatient. They were also found to be more likely to be younger and more experienced at the time of the reported accident.

8.6: ACCIDENT AVOIDANCE & PREVENTION

8.6.1 DFA to Predict Use of Accident Avoidance Measures at Junctions

During Section 2 of the questionnaire, concerning accident details, respondents were asked to state which techniques, if any, they had used in order to avoid the collision. It was therefore felt to be of interest to investigate factors related to whether such an avoidance measure was selected or omitted. However, it is recognised that the adoption of an avoidance measure, and the particular form of measure adopted, is largely dependent upon the specific nature of each individual situation and therefore it is recommended that this is accounted for when the results of this analysis are considered. Despite this reservation, it is suggested that certain demographic or other factors may ensure that a driver is more ably equipped to deal with situations in which avoidance is necessary and it is the intention that this analysis may reveal such factors.

In line with previously-reported analyses, a stepwise discriminant function analysis was performed using a variety of descriptive variables and metavariables to discriminate between drivers who did not adopt any form of avoidance measure and those who did adopt such a measure. In addition to the twelve metavariables outlined in Section 8.3, the descriptive variables included in this analysis were: SEX; AGEACC; ACCEXP; MILES; ADTRAIN; DRSCHOOL; FRIEND; LESSONS; DRWORK; PACC; TESTTIM; TESTAGE; VEHBEL; VEHICLE; ACCS; MOTORCYC; HGV; and PSV. The analysis, described in full in Section DD.5 of Appendix DD, is summarized in Table 8.23 (below).

Table 8.23: Summary of DFA using Metavariables to Predict Use of Accident Avoidance Measures

DFA Solution: (N=202)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.109	0.313	9.80	0.001	62.85	1	DRSCHOOL	-0.642
						2	MILES	0.525
						3	OPINFAC2	0.406
						4	DRWORK	0.523
						5	UDPFAC2	0.310

The DFA solution to predict adoption of accident avoidance measures outlined in Table 8.23 produced a relatively small canonical correlation (0.3) and could only account for just under 10% of the variance. However, the function was found to be significant at the 0.1% level and almost 63% of cases were correctly classified, translating into a z-score of 4.09 ($p<0.001$). From Table DD.21 (Appendix DD) it can be seen that the solution was a more efficient predictor of drivers who did not adopt an avoidance measure than those who did.

Five variables were retained in the final equation and the strongest predictor variable was found to be DRSCHOOL, the group centroids (see Appendix DD) indicating that those drivers not adopting any form of avoidance measure were more likely to have received pre-test tuition from a driving school. In addition, these drivers were found to: have a lower annual mileage (MILES); report being better attenders of vulnerable road users at junctions (OPINFAC2); be less likely to drive as part of their work (DRWORK); and to believe that careless junction negotiation practices are more likely to result in an accident (UDPFAC2).

8.6.2 DFA to Predict Subjective Assessments of Junction Accident Preventability

Accident-involved respondents had a chance to state up to two ways in which they felt both themselves and another party could have prevented the accident. It is suggested that, in the majority of cases, there is always *something* that a driver could have done to prevent, or perhaps minimise, the impact, regardless of the circumstances. However, many respondents chose to suggest that there was nothing they could have done to prevent the described accident. In other words, they claimed to be effectively helpless in that situation and it was felt that a discriminant analysis such as those performed in previous sections may be able to highlight differences between these 'accident-preventable' and 'accident non-preventable' drivers. The larger number of cases available for this analysis meant that more descriptive variables than used in some previous analyses could be included. Those included were: SEX; AGEACC; ACCEXP; MILES; LESSONS; ADTRAIN; PACC; VEHBEL; and DRWORK. Table 8.24 (over) shows the summary statistics from this analysis whilst the full tables are presented in Section DD.6 of Appendix DD. It should be noted that only accidents which occurred at junctions were considered.

This analysis was equally successful as that outlined in Section 8.5.2, and the solution achieved a canonical correlation of over 0.45 and accounted for over 20% of the variance. Just under 72% of cases were correctly classified by the solution, resulting in a high z-score of 5.47 ($p.<0.001$).

Table 8.24: Summary of DFA using Metavariables to Predict Junction Accident Preventability

DFA Solution: (N=144)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.265	0.458	20.94	0.001	71.70	1	DESCFAC2	0.486
						2	ADTRAIN	0.313
						3	UDPFAC1	0.194
						4	ACCEXP	0.164
						5	DRWORK	-0.167
						6	AGEACC	0.003
						7	INCPFAC2	-0.302
						8	PACC	-0.283
						9	REPOFAC1	-0.291
						10	UDPFAC2	0.288
						11	UDPFAC1*	-
						12	INCPFAC1	0.172
						13	UDPFAC4	0.036

NB: * - Denotes variable removed from analysis.

In the final solution, twelve variables were retained, with an additional one (UDPFAC1) removed at Step 11 after initial inclusion at Step 3. DESCFAC2 and ADTRAIN proved to be the most effective discriminators, with the 'accident preventable' group of drivers giving more negligent self-descriptions (DESCFAC2) and being more likely to have received additional training. From the group centroids (see Appendix DD), it can be seen that these drivers who felt that they could have done something to prevent the accident were also: more experienced at the time of the accident (ACCEXP); less likely to drive as part of their work (DRWORK); more likely to be younger (AGEACC); more likely to feel that their chances of accident-involvement are governed by driver factors (INCPFAC2); more likely to believe that the average driver has a greater chance of accident-involvement than themselves (PACC); less likely to report being better attenders of vehicles in front and to being less impatient (REPOFAC1); less likely to believe that careless junction negotiation practices will result in an accident (UDPFAC2); less likely to believe that their chances of accident-involvement are governed by environmental factors (INCPFAC1); and that environmental or external factors are more likely to result in an accident at a junction in general (UDPFAC4).

8.6.3 Relationship of Opinions Concerning Accident Preventability to Admissions of Culpability

The analyses in Sections 8.5.2 and 8.6.2 described discriminant function analyses to predict admission of accident culpability and preventability respectively. It seems reasonable to assume that the will be some relationship between these two factors and it was therefore felt that it would be useful to determine the extent of this relationship. Table 8.25 (below) shows the number of respondents falling into each of the four possible categories, followed, in parentheses, by the row and then column percentages. These details are followed by a chi-square analysis, and accompanying statistics.

The results clearly show that respondents who admitted responsibility for the described accident, and were deemed culpable by independent raters, were significantly far less likely to report feeling that there was nothing they could have done to prevent that accident. More importantly, the lambda statistics shown in the above table all reveal a large degree of predictive ability. The figures suggesting that information about a respondent's 'ADMIT' score will reduce the probability of error in predicting their 'YPREV1' score by over 43%, whilst in the reverse situation, the error reduction probability is just under 43%.

Table 8.25: Relationship of Accident Preventability to Admission of Culpability

Preventability: (YPREV1):	Admission of Culpability (ADMIT): Deny	Admit	TOTAL
Not preventable	39 (70.9%) (72.2%)	16 (29.1%) (20.8%)	55 (100.0%) (42.0%)
Preventable	15 (19.7%) (27.8%)	61 (80.3%) (79.2%)	76 (100.0%) (58.0%)
TOTAL	54 (41.2%) (100.0%)	77 (58.8%) (100.0%)	131 (100.0%)

Chi-Square	= 34.485
Deg. Free.	= 1
Significance	= 0.000
Lambda (Symmetric)	= 0.431
Lambda (YPREV1 dependent)	= 0.436
Lambda (ADMIT dependent)	= 0.426

8.6.4 Summary of Section 8.6

The discriminant analysis designed to predict adoption of accident avoidance measures could only account for under 10% of the variance although a significantly high proportion of cases were correctly classified by the solution. Of the individual predictor variables, DRSCHOOL was the most successful with the drivers who did not adopt an avoidance measure being more likely to have been trained by a qualified driving instructor.

The following DFA designed to predict respondents' feelings of power to prevent the described accident from occurring produced a reasonable solution, accounting for over 20% of the variance and classifying over 70% of cases correctly. The variables DESCFAC2 and ADTRAIN were found to be the best predictors of accident 'preventability', indicating that those respondents who felt that they could have done something to prevent the accident described themselves as being more negligent and were also more likely to have received additional training. A brief chi-square analysis was then performed to ascertain the relationship between feelings of accident preventability and admission of accident culpability. The results showed a strong relationship, with the accident admitters more likely to feel that there was something they could have done to prevent the accident.

8.7: ANALYSIS OF MAJOR ACCIDENT CLASSES

8.7.0 Overview

The observation study revealed several interesting aspects of driving at junctions, and it was felt that it would be useful to determine how responses to certain items of the questionnaire related to these earlier findings. In particular, three main types of incident (rear-end shunts, left-turn and cross-traffic incidents) were found to be especially problematical, as witnessed by the accident statistics and instances of near-misses. This section of Chapter 8 will focus upon issues related to these manoeuvres.

8.7.1 Accident Avoidance Tactics Employed by Respondents Involved in the Three Major Forms of Accident

In Section 8.2.5, the accident avoidance measures adopted by respondents were listed for all accident types. However, it was felt that this grouping together may obscure useful information relating to the major accident forms, and Table 8.26 (below) lists the number of respondents involved in each form of accident that claimed to use each avoidance measure. As with Table 8.9, the percentages do not add to 100% as respondents had the option of providing up to two avoidance procedures. The figures in parentheses are the valid percentages for each accident type.

Table 8.26: Avoidance Procedures Employed by Respondents Involved in Major Accident Types

Avoidance Procedure:	Accident Category: Rear-End Shunt (N=71)	Left-Turn (N=21)	Cross-Traffic (N=43)
None adopted	14 (19.7)	10 (47.6)	20 (46.5)
Braking	50 (70.4)	7 (33.3)	9 (20.9)
Swerving	10 (14.1)	4 (19.0)	9 (20.9)
Stopping	4 (5.6)	2 (9.5)	5 (11.6)
Accelerating	0 (-)	1 (4.8)	3 (7.0)
Other	1 (1.4)	0 (-)	3 (7.0)

Table 8.26 does indeed reveal some interesting factors concerned with accident avoidance measures when split between the alternative accident forms. The most notable features include the low number of rear-end shunt accident-involvees claiming that they did not implement any avoidance manoeuvre in relation to those drivers involved in the other two forms of accident listed in the table. Additionally, a higher proportion of these 'rear-end shunt' drivers used braking as an avoidance technique and it is perhaps not surprising that none of them used acceleration to avoid the accident. The left-turn and cross-traffic-involved respondents showed a certain degree of correspondence with one another, with almost half of the respondents in each group stating that no avoidance tactics were used.

8.7.2 Accident Prevention Tactics Suggested by Respondents Involved in the Three Major Forms of Accident

In addition to the accident avoidance measures, it was felt that it would be productive to investigate the types of accident prevention measures advocated by respondents involved in the three types of accident dealt with in this section. Table 8.27 (below and over) lists the prevention methods suggested by drivers involved in all three forms of accident for both themselves and for another party. Once again, the figures in parentheses are the valid percentages for each accident type and the column totals do not equal 100% due to the opportunity respondents' had to suggest more than a single prevention measure.

Table 8.27: Accident Prevention Measures for the Three Major Types of Accident: Self and Others

	Rear-End Shunt (N=71)		Left-Turn (N=20)		Cross-Traffic (N=41)	
	Self	Other	Self	Other	Self	Other
Nothing	20 (28.2)	32 (45.1)	7 (35.0)	6 (30.0)	23 (56.1)	13 (31.7)
Not performed manoeuvre	1 (1.4)	4 (5.6)	2 (10.0)	2 (10.0)	1 (2.4)	3 (7.3)
Driven more slowly	5 (7.0)	2 (2.8)	2 (10.0)	9 (45.0)	0 (-)	15 (36.6)
Been more observant/careful	40 (56.3)	7 (9.9)	7 (35.0)	1 (5.0)	7 (17.1)	7 (17.1)
Been more decisive	1 (1.4)	17 (23.9)	0 (-)	0 (-)	1 (2.4)	0 (-)

(cont. over)

Table 8.27: Accident Prevention Measures for the Three Major Types of Accident: Self and Others (cont.)

	Rear-End Shunt (N=71)		Left-Turn (N=20)		Cross-Traffic (N=41)	
	Self	Other	Self	Other	Self	Other
Junction altered by authorities	0 (-)	2 (2.8)	0 (-)	2 (10.0)	0 (-)	3 (7.3)
Waited/hesitated	5 (7.0)	1 (1.4)	4 (20.0)	0 (-)	10 (24.4)	1 (2.4)
Signalled intentions/ been more visible	0 (-)	3 (4.2)	0 (-)	1 (5.0)	0 (-)	1 (2.4)
Adopted better road position	6 (8.5)	3 (4.2)	0 (-)	0 (-)	0 (-)	1 (2.4)
Swerved	0 (-)	1 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)
Remained calm	1 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Other	2 (2.8)	6 (8.5)	0 (-)	0 (-)	1 (2.4)	2 (4.9)

One revealing aspect of the above table is the relatively high proportion (45.1%) of 'rear-end shunt' drivers who felt the other party could have done nothing to prevent the described accident, whilst only 28.2% of these drivers felt that they were powerless in the situation. Well over half of these respondents felt that they could have been more observant, whilst only blaming lack of observation upon 9.9% of other road users. Decisiveness was the main prevention category the 'rear-end shunt' accident-involvees felt that another party should have employed.

Those respondents involved in left-turn accidents claimed that the other party should have driven more slowly in a higher proportion of cases than they felt they should have themselves. However, these drivers pleaded guilty to not being as observant as they should have been more often than they blamed the other party for this lack of observation. The other notable factor emerging from this column was the relatively high proportion (20%) of drivers who felt that they should have waited before performing the manoeuvre, whilst not blaming another party for this impatience on any occasion.

Finally, the cross-traffic accident-involvees claimed to be powerless to prevent the accident in more examples of the accident than another party (56.1% against

31.7% respectively). These respondents also reported feeling that the other party could have driven more slowly in over a third (36.6%) of the cases, but never felt that the same applied to themselves. However, a higher proportion (24.4%) of 'cross-traffic' drivers felt that they should have waited before moving, but on only a single occasion (representing 2.4% of cases) did they feel that another party should have done the same.

8.7.3 DFA using Metavariables to Predict Involvement in the Main Types of Junction Accidents

Finally, it was felt that it would be useful to determine the extent to which the set of metavariables used elsewhere in this chapter were able to discriminate between the various forms of accidents described in this section. In a similar manner to the accident liability analysis described in Section 8.4, the first analysis, a stepwise DFA, shown in Table 8.28 (below) compares non-accident-involved drivers with those involved in rear-end shunt accidents.

In the case of the left-turn accidents, it was found that there were insufficient respondents of the left-turn accident type to incorporate into a single analysis. It may be remembered from Chapter 5 (Section 5.3.3) that cross-traffic and left-turn manoeuvres were found by Darzentas et. al. (1980) to produce similar gap acceptance times in drivers, and it is argued that, on this basis, the problem of insufficient left-turn cases may be overcome by combining these accidents with those resulting from cross-traffic manoeuvres. Therefore, the analysis summarized in Table 8.29 (over) discriminates between left-turn/cross-traffic accidents and non-accident-involved drivers.

Both of these discriminant analyses incorporated just three demographic variables (SEX, AGE and YEARSDR) as there were insufficient accident-involved drivers to allow for the inclusion of further variables. Additionally, the use of the non-accident-involved group meant that current age and experience, rather than those at the time of the described accident, had to be included. These analyses are detailed in Section DD.7 of Appendix DD.

Table 8.28: Summary of DFA Using Metavariables to Predict Involvement in Rear-End Shunt Accidents

DFA Solution: (N=119)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probab-ility of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.093	0.292	8.51	0.037	65.65	1	SEX	0.764
						2	UDPFAC1	-0.162
						3	INCPFAC1	0.119
						4	INCPFAC2	-0.433

The analysis summarized in Table 8.28 is not particularly strong, with a canonical correlation of under 0.3, accounting for 8.51% of the variance. However, the function was significant and over 65% of cases were correctly classified (z=3.58, p.<0.001). By far the most effective discriminator of the two groups was found to be SEX, the group centroids (see Appendix DD) revealing that the rear-end shunt accident-involved drivers were more likely to be male. Regarding the other predictor variables, the rear-end accident-involved drivers were found to be: more likely to believe that driver variables will affect their chances of becoming accident-involved (INCPFAC2); less likely that their future accident-involvement likelihood is dependent upon external factors (INCPFAC1); and that careless junction approach behaviours are more likely to result in an accident (UDPFAC1).

Table 8.29: **Summary of DFA Using Metavariables to Predict Involvement in Left-Turn/Cross-Traffic Accidents**

	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probab-ility of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
DFA Solution: (N=106)								
	0.177	0.388	15.06	0.001	68.38	1	UDPFAC1	0.744
						2	SEX	-0.601
						3	REPOFAC1	0.191

This analysis was slightly more robust than the previous one, achieving a canonical correlation of almost 0.4 and accounting for over 15% of the variance. A slightly higher proportion of cases were correctly classified, the 68.4% translating into a z-score of 3.98, significant beyond the 0.1% level. UDPFAC1 and SEX emerged as the best predictors, with the left-turn/cross-traffic accident-involvees more likely to believe that careless junction approach behaviours will result in an accident and more likely to be male. The only other predictor included in the final solution was REPOFAC1, which indicated that these accident-involved drivers had a tendency to report being poor attenders of vehicles in front and to impatience.

8.7.5 Summary of Section 8.7

When the accident avoidance measures taken by respondents involved in each of the three main categories of accident were considered, it was found that drivers involved in left-turn and cross-traffic accidents adopted no avoidance tactic on proportionally more occasions than those involved in rear-end shunts. However, this latter category of driver adopted a braking avoidance technique more often than those involved in the other accidents. Accident prevention measures, both for the respondent and for another party, were also considered. Respondents involved in rear-end shunt accidents felt that the other party was powerless to prevent the accident in more examples than they were able to do this themselves. The main prevention category suggested by these drivers was an increased level of observation should have been applied. Drivers involved in left-turn accidents also reported that they could have prevented the accident by being more observant, but felt that other drivers could have prevented the accident by driving more slowly. Finally, a high proportion of the cross-traffic accident-involved respondents also felt that the other driver should have driven more slowly, but believed themselves to be powerless to prevent the accident in more cases than they reported the other party to be unable to prevent the accident.

The analysis performed to discriminate between the main accident types and all other junction accidents produced very similar but relatively poor functions that accounted for small proportions of the overall variance. Males were found to be over-represented in both classes of accident-involved drivers, as were those believing that careless junction approach practices will result in an accident. The rear-end accident-involved drivers felt that driver variables most influenced their future accident-involvement chances, whilst worse attendance to vehicles in front and impatience separated the left-turn/cross-traffic accident-involvees from those not involved in any accidents.

8.8: PREDICTION OF SELF-CENTRED/ILL-MANNERED SELF DESCRIPTIONS

8.8.1 Multiple Regression to Predict Scores on DESCFAC1

In a number of analyses described within this chapter, the metavariable DESCFAC1 emerged as an extremely strong predictor. In Section 8.4.1, this metavariable was found to be a good predictor of accident liability even when demographic factors such as sex, experience and exposure were taken into account. In addition, DESCFAC1 was also found to be one of the most effective predictors of junction accident liability (Section 8.4.2) and admission of accident culpability (Section 8.5.2). In these examples, a high DESCFAC1 score, indicative of a self-centred/ill-mannered driver, was found to be implicated in accident liability and admission of culpability.

It was therefore felt to be of interest to uncover which drivers scored more highly on this metavariable and to highlight which demographic or descriptive variables are good predictors of drivers who give self-centred/ill-mannered self-descriptions. A stepwise multiple regression, as described in Section 8.4.1, was performed using descriptive variables to predict scores on DESCFAC1. The predictors included were: AGE; SEX; VEHICLE (whether the most-driven vehicle was a car or another type of vehicle); VEHBEL; MOTORCYC; HGV; PSV; DRWORK; TESTAGE (the age at which the respondent passed the driving test); TESTTIM (the number of times the car test was taken); LESSONS; DRSCHOOL; FRIEND; ADTRAIN; YEARSDR; MILES; MOTORWAY; RURAL; URBAN; UNFAMIL; PACC; ACCS (the number of accidents the respondent reported having been involved in). The full details of this analysis are presented in Section DD.8 in Appendix DD whilst the main points are summarized in Table 8.30 (over).

Although a large number of predictor variables were included in the analysis, the large number of cases ensured that the case-to-variable ratio was in excess of 24.4:1. The solution produced a multiple R of over 0.4 and the amount of variance accounted for by this solution, as given by the value for adjusted R^2, was 16.7%. This was found to be significant beyond the 0.1% level.

The regression took seven steps to reach the final solution and by far the most important predictor of DESCFAC1 was found to be AGE. The signs indicate that there is an inverse relationship between the respondents age and their score on this metavariable, with the more self-centred and ill-mannered drivers being younger in general. The six additional variables included in the equation indicated that these more self-centred/ill-mannered drivers were also: more accident-liable (ACCS); more likely to be males (SEX); more likely to believe that they were more vulnerable to accidents than the average driver (PACC); less likely to be qualified public service vehicle drivers (PSV); drive less on unfamiliar routes (UNFAMIL); and drive more on motorways (MOTORWAY).

Table 8.30: Summary of Multiple Regression using Metavariables to Predict Scores on DESCFAC1

Regression Solution: (N=537)	Multiple R	R^2	Adjusted R^2	F	Significance of F	Step	Variable	B	Beta
DESCFAC1	0.418	0.175	0.165	17.253	0.000	1	AGE	-0.184	-0.335
						2	ACCS	0.836	0.167
						3	SEX	1.625	0.127
						4	PACC	-0.441	-0.105
						5	PSV	-4.715	-0.100
						6	UNFAMIL	-0.041	-0.115
						7	MOTORWAY	0.027	0.085
						(Constant)		33.763	

8.8.2 Summary of Section 8.8

This section described a multiple regression analysis using descriptive information to predict levels on the metavariable found to be implicated in accident-involvement in previous analyses - DESCFAC1. The analysis produced a reasonably robust solution, accounting for over 16% of the overall variance. The age of respondents was found to be the most accurate predictor of DESCFAC1, with younger drivers tending to describe themselves as being more self-centred and ill-mannered. However, these latter drivers were also found to be more accident-involved, more likely to be male and less likely to be qualified public service vehicle drivers.

8.9: TRAINING ISSUES

8.9.0 Overview

It may be recalled from the discussion in Section 1.4 that it was concluded that the most effective method of bringing about behavioural change in drivers was through training. The questionnaire was designed to incorporate several items relating to driver training, and this section aims to explore briefly issues concerned with driver training.

8.9.1 Descriptive Statistics Relating to Driver Training

Table 8.31 (below) summarises the frequencies obtained for respondents in each sample on some of the major training-related variables, including the main form of novice driver training received and if additional training of any form was taken.

Table 8.31: Summary of Descriptive Statistics Relating to Driver Training for each Sample

	Sample:			
	GEN	MK	PAR	TOTAL
No training received	1 (0.3)	1 (0.6)	0 (0.0)	2 (0.3)
Most training received from qualified instructor	239 (61.1)	109 (64.1)	98 (64.9)	446 (62.6)
Most training received from friend/relative	60 (15.3)	22 (12.9)	18 (11.9)	100 (14.0)
Trained received from instructor and relative in equal proportions	91 (23.3)	38 (22.4)	35 (23.2)	164 (23.0)
Number of drivers with additional training	30 (7.6)	8 (4.7)	20 (13.2)	58 (8.1)

The above table reveals that there are minimal differences between the samples in the proportions of novice training received. Only respondents from the GEN sample showed slight differences, with these drivers on the whole receiving less training from a qualified instructor and more from a friend or relative. Perhaps the most significant finding from Table 8.31 is the relatively high proportion of respondents from the PAR sample who indicated that they had been in receipt of some form of additional training. Over 13% of drivers in this accident-involved sample had received additional training, in contrast with the 7.6% and 4.7% of respondents from the GEN and MK samples.

Various forms of additional training are available to drivers, and so far no distinction has been made between the different forms. Table 8.32 (below) lists the types of post-test training reported by the 58 respondents, along with the valid percentages.

Table 8.32: Types of Additional Training Reported

Additional Training Source:	Frequency of Citation	Valid %
Institute of Advanced Motorists (IAM) Test	20	34.5
Heavy Goods vehicle test	8	13.8
Public Service vehicle test	3	5.2
Skid control course	1	1.7
Police driving course	13	22.4
'Home Office Class One'	1	1.7
IAM test - lessons only taken	4	6.9
RAC motorcycle course	2	3.4
'Training School'	1	1.7
Post Office driving course	2	3.4
Ambulance driving course	1	1.7
IAM motorcycle test	1	1.7
'Milton Keynes Advanced Driving Assessment'	1	1.7

Table 8.32 shows that over a third of those drivers who have taken some form of additional training took the Institute of Advanced Motorists test, with four additional respondents taking just the lessons for the IAM test. The majority of the other categories involve some form of additional driving qualification connected with the respondents' work. The most frequently-cited example of this was the 22.4% who reported having taken part in the police driving course. An additional 13.8% and 5.2% of respondents cited the heavy goods vehicle and public service vehicle tests respectively.

8.9.2 Accident-to-Mileage Ratios According to Training Received

Section 1.4.2 of the literature review reported the finding of Skelly (1968) that drivers who had received no tuition from a professional driving school had the best (ie. highest) miles-per-accident ratio. Similar information was collected in this study, and it was felt that it would be useful to determine if the effect was present in the sample. Table 8.33 (below and over) shows the mean number of accidents, driving experience (a product of miles driven per year and number of years driving on a regular basis) and the ratio between the two for respondents reporting having received each of the three possible forms of novice (ie. pre-test) driving tuition: from a qualified instructor only; from a friend or relative only; and from a roughly equal combination of the two previous categories. In addition, it was felt that receipt of additional (ie. post-test) training may also affect miles-per-accident ratios, and this information is also incorporated in Table 8.33.

Table 8.33: Accidents, Mileage and Accident-to-Mileage Ratios for each Combination of Pre- and Post-Test Training Received

	Pre-Test Training:			
	Qualified Driving Instructor	Friend or Relative	50% of each	TOTAL
No Advanced Training:				
Mean Number of Accidents per Respondent	0.92 (1.20) (412)	1.03 (1.41) (89)	0.78 (1.10) (153)	0.90 (1.21) (658)
Mean Driving Experience (Mileage x 1000)	203.726 (331.017) (398)	391.793 (361.398) (87)	200.093 (199.794) (150)	229.369 (315.535) (639)
Mean Experience to-Accident Ratio	161.043 (280.880) (398)	308.317 (324.467) (87)	161.209 (174.523) (150)	182.260 (270.693) (639)

(cont. over)

Table 8.33: Accidents, Mileage and Accident-to-Mileage Ratios for each Combination of Pre- and Post-Test Training Received (cont.)

	Pre-Test Training:			
	Qualified Driving Instructor	Friend or Relative	50% of each	TOTAL
Advanced Training:				
Mean Number of Accidents per Respondent	1.12 (1.45) (33)	1.18 (0.87) (11)	1.18 (1.78) (11)	1.10 (1.39) (58)
Mean Driving Experience (Mileage x 1000)	417.813 (296.517) (32)	287.100 (184.721) (10)	247.364 (267.698) (11)	358.964 (271.712) (56)
Mean Experience to-Accident Ratio	330.000 (222.067) (32)	211.600 (138.018) (10)	161.621 (134.806) (11)	278.461 (200.140) (56)
TOTAL:				
Mean Number of Accidents per Respondent	0.93 (1.22) (446)	1.05 (1.36) (100)	0.80 (1.16) (164)	0.93 (1.28) (740)
Mean Driving Experience (Mileage x 1000)	219.658 (333.041) (430)	381.000 (348.176) (97)	203.323 (204.439) (164)	243.692 (319.644) (717)
Mean Experience to-Accident Ratio	173.617 (280.255) (430)	298.346 (311.404) (97)	161.237 (171.756) (164)	193.212 (274.989) (717)

NB: It should be noted that some discrepancies appear in the above table and the figures in the final 'TOTAL' column do not always correspond with the totals implied by the figures in the individual columns. This is due to the effect of missing values on the variable TUITION (ie. pre-test training).

Although the driving experience measure is an admittedly crude one, assuming that each respondent had driven the same amount of annual mileage over the period of time they had been driving on a regular basis, it is argued that it is the most effective measure available. The final section of Table 8.33 reveals that, in concordance with the findings of Skelly (op. cit.), those drivers who received training mainly from a friend or relative had the best miles-per-accident record, driving an average of almost 300,000 miles per accident, despite also having the highest accident-per-respondent ratio. The worst record, in which respondents drove a mean of just over 160,000 miles per accident, was shown to be held by those drivers who had received an equal mixture of training from a qualified instructor and a friend or relative. Those drivers mainly in receipt of training from a qualified instructor reported a miles-per-accident ratio slightly better than the mixed training group, with a ratio just in excess of 170,000.

It is interesting to note that, when advanced training is considered, the situation alters somewhat. Although the relative merits of figures for drivers who have not received post-test training are roughly the same as the overall figures (mainly because this group contributed over 90% of the cases to those overall figures), the situation for drivers in receipt of additional training follows a different pattern. Firstly, it is noteworthy that, overall, receipt of advanced training increases the mileage-accident ratio considerably (278.461 compared with 182.260 thousand miles-per-accident for drivers not in receipt of advanced training). However, it is notable that the combination of advanced driving and pre-test instruction from a qualified instructor produced the most successful miles-per-accident ratio. The table reveals that the least successful pre-test training method, if advanced training is taken, is the equal combination of qualified and unqualified instruction.

Despite these obvious differences, it was decided to test for the major sources of variance in accident counts and an analysis of variance was performed using the type of novice driver training (TUITION) and whether advanced training (ADTRAIN) was taken as the independent variables. A two-way design was selected so that the individual merits of pre- and post-test training could be assessed along with the interaction between the two. However, rather than using the miles-per-accident ratios as the dependent variable, it was decided that it would be more applicable to use the mean number of accidents and include both exposure (measured by annual mileage - MILES) and experience (measured by the number of years since the driving test was taken - YEARSDR) as covariates. That way, any differences due to these factors can be separated from those due to the varying levels of the independent variables. This ANCOVA is summarized in Table 8.34 (over). H_0 in this example is that the number of accidents for all six samples are from the same population and therefore no significant differences (adopting an alpha level of 0.05) between these groups will be demonstrated.

Table 8.34: ANCOVA Summary Table for Mean Number of Accidents for each Combination of Pre- and Post-Test Driving Tuition

Source	Deg. Free.	Sum of Squares	Mean Squares	F-Ratio	F-Prob.	Est w^2
Covariates:						
YEARSDR	1	11.152	11.152	7.798	0.005	0.009
MILES	1	56.495	56.495	39.505	0.000	0.053
Main Effects:						
TUITION	2	1.629	0.815	0.570	0.566	0.000
ADTRAIN	1	0.193	0.193	0.135	0.713	0.000
Interaction	2	1.462	0.713	0.499	0.608	0.000
Explained	7	70.743	10.106	7.067	0.000	
Residual	679	971.013	1.430			
Total	686	1041.755	1.519			

Table 8.34 reveals that, whilst the covariates were found to significantly differ between the groups, the same was not true of the main effects, nor their interaction term, each of which produced non-significant F-Ratios. This suggests that the vast majority of the variance in accident rates is explained by exposure and experience factors, whilst virtually none is explained by the form of pre-test tuition received nor the receipt, or not, of advanced training. However, the estimates of omega-squared showed that YEARSDR and MILES could only account for 0.9% and 5.3% of the variance respectively. It is therefore recommended that H_0, in which it was stated that the number of accidents will not significantly differ between the group, is not rejected.

8.9.3 Effects of Alternative Forms of Tuition

8.9.3.1 DFA Investigating the Effects of Type of Novice Driver Training Received

Although it was established in the previous section that the accident rates of drivers does not appear to vary according to the type of pre-test training received, it was felt that it would be interesting to attempt to establish any factors which may be able to discriminate between drivers who received each of the basic forms of pre-test training. Therefore, a three-group stepwise discriminant function analysis, using the three types of novice driver training as the dependent variable, was performed. Case-to-variable restrictions were unlikely to be violated in this analysis and therefore a wide range of descriptive variables were included into the analysis: AGE; SEX; YEARSDR; MILES; TESTAGE; TESTYRS; TESTTIM; ADTRAIN; MOTORCYC; HGV; PSV; DRWORK; PACC; VEHBEL; VEHSPEC; ACCS.

The analysis is summarized in Table 8.35 (below) and the full details, including the means and standard deviations for all independent variables for each of the three groups, can be found in Section DD.9 in Appendix DD. Figure 8.1 (below) shows the group centroids for the two functions.

Table 8.35: **Summary of DFA Predicting Type of Novice Driver Training Received**

DFA Solution: (N=171)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients	
								Function 1	Function 2
Function 1	0.260	0.454	20.63	0.000		1	YEARSDR	0.770	-0.465
					55.81	2	VEHBEL	-0.275	-0.380
Function 2	0.150	0.361	13.04	0.004		3	PACC	0.106	0.484
						4	UDPFAC1	0.066	0.175
						5	VEHSPEC	-0.156	-0.060
						6	DESCFAC1	0.078	0.323
						7	DESCFAC2	-0.128	0.016
						8	DESCFAC3	-0.054	0.225
						9	HGV	0.052	0.279

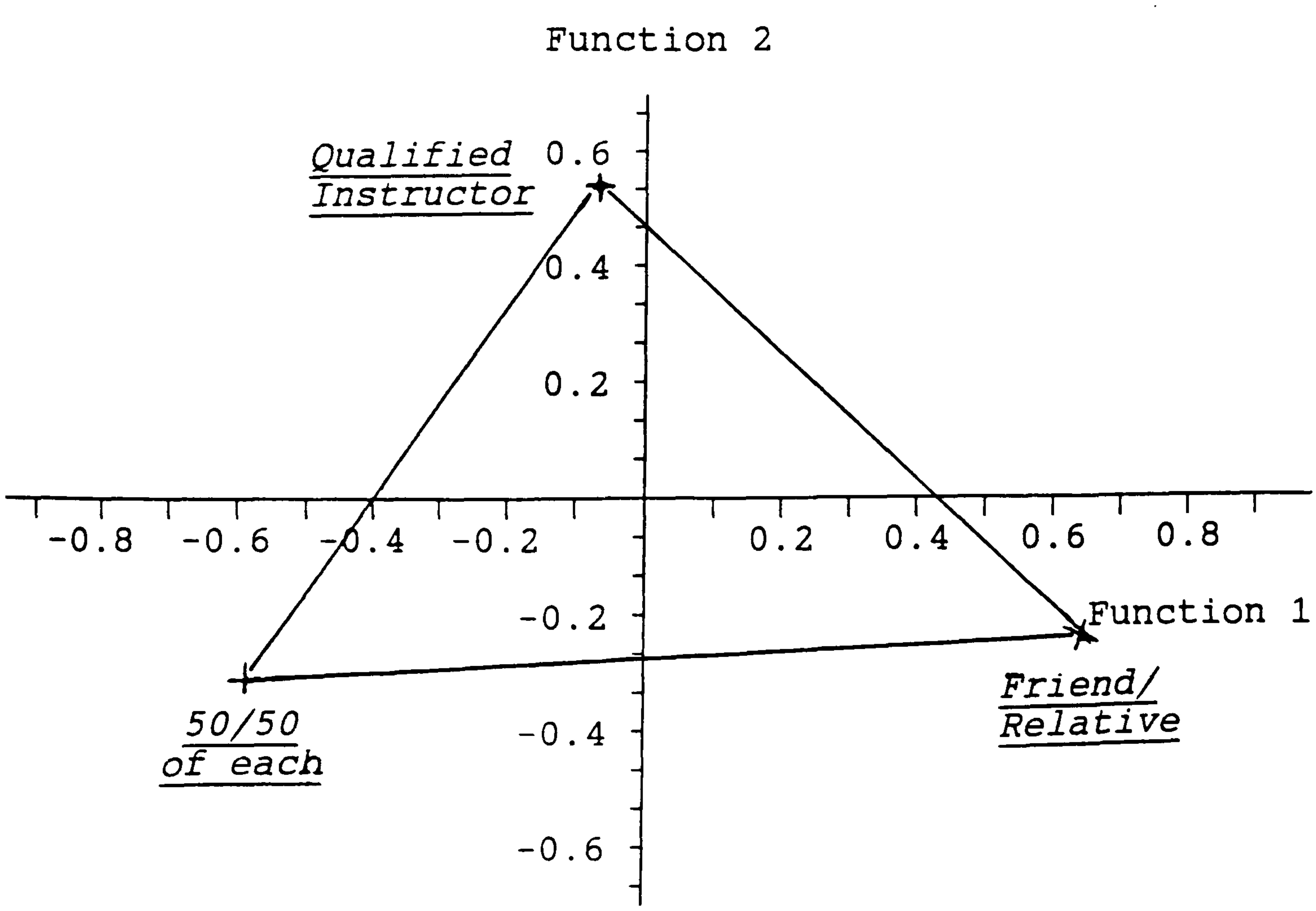

Figure 8.1: **Group Centroids for DFA Predicting Type of Novice Driver Training Received**

The solution summarized in Table 8.35 reveals a very satisfactory analysis, with the two function achieving canonical correlations of 0.45 and 0.36, accounting for over 20% and 13% respectively. The functions were significant at the 0.1% and 1% levels respectively, and the final nine-variable solution correctly classified over 55% of the cases ($z=6.99$, $p.<0.001$).

Figure 8.1 shows that the first function mainly serves to discriminate between those drivers trained by a friend or relative and those receiving tuition from a mixture of a professional instructor and a friend or relative. The second function groups the drivers trained by a friend or relative with those trained by a mixture of the two types and contrasts them with those trained mainly by a qualified instructor.

The most effective predictor of tuition type was found to be the amount of driving experience reported (YEARSDR), with those trained by a friend/relative only being the most experienced and those trained by a professional instructor the least. Those trained by a combination of the two forms of training were also distinguishable from those trained by a friend or relative in that the former group's most-driven vehicle was more likely to be their own (VEHBEL). In addition, these former drivers were found to be differentiated from those in the latter group in that they reported being: more likely to drive a high performance vehicle (VEHSPEC); more negligent (DESCFAC2); and more likely to be involved in an accident during the next twelve months than the average driver (PACC).

In contrast, those trained by a qualified instructor were found to differ from those falling into the other two groups in terms of their being: more likely to believe that the average driver has a higher chance of becoming involved in an accident than themselves (PACC); less likely to drive their own vehicle (VEHBEL); more likely to describe their driving as self-centred/ill-mannered (DESCFAC1); more likely to be qualified heavy goods vehicle drivers (HGV); more likely to describe themselves as more timid (DESCFAC3); and less likely to believe that careless junction approach styles will result in an accident.

8.9.3.2 DFA Investigating the Effect of Advanced Training

Some researchers (eg. Fazakerley et. al. (1980) - see Section 1.4.3) have found that attendance on advanced driving courses improved the knowledge and performance of drivers. In light of this, and the revealing findings of the previous analysis, it was decided to perform a similar DFA, this time discriminating between those drivers who had been in receipt of advanced training, and those who had not. Due to the low number of drivers in the advanced training group, some descriptive variables had to be dropped to avoid violating case-to-variable ratio considerations. Those included were: AGE; SEX; YEARSDR; ACCS; DRWORK; TESTAGE; and LESSONS. The two-group DFA performed is detailed in Section DD.9 of Appendix DD, and summarized in Table 8.36 (below).

Table 8.36: Summary of DFA Predicting Receipt of Advanced Training

DFA Solution: (N=85)	Eigenvalue	Canonical Correlation	% Variance Accounted For	Probability of Function	% Cases Correctly Classified	Step	Variable	Pooled Within-Groups Correlation Coefficients
	0.542	0.593	35.14	0.000	74.00	1	REPOFAC1	0.446
						2	DRWORK	0.394
						3	UDPFAC2	0.304
						4	UDPFAC1	-0.070
						5	OPINFAC2	-0.422

The solution produced is very strong, with an eigenvalue in excess of 0.54 and over a third of the overall variance accounted for. Almost three-quarters (74.0%) of the cases were correctly classified by the solution, translating into a z-score of 4.80 (p.<0.001), and five variables were retained in the final solution. From the group centroids given in Appendix DD it can be deduced that drivers who had embarked upon some form of advanced training were: more likely to report being better attenders to vehicles in front and more patient (REPOFAC1); more likely to drive as part of their work (DRWORK); less likely to believe that careless junction negotiation practices will result in an accident (UDPFAC2); more likely to feel that careless junction approach styles will result in an accident (UDPFAC1); and more likely to consider vulnerable road users at junctions (OPINFAC2).

8.9.4 Summary of Section 8.9

There were shown to be minimal differences in the proportions of pre-test training received by respondents in the three samples, although a considerably higher proportion of drivers from the PAR sample were found to have had some form of additional training. The most common form of post-test training was found to be the test offered by the Institute of Advanced Motorists.

Mileage-to-accident ratios were compared for respondents who had been in receipt of each of the three classes of pre-test training defined, as well as when supplemented with advanced training. Those in receipt of tuition mainly from a friend or relative were discovered to have the safest record, with those in receipt of a mixture of the two forms of training having the lowest (and therefore worst) mean ratio, a result shown to be statistically significant. In addition, those drivers in receipt of advanced training were shown to have a higher ratio than those who had not, although the best overall combination was found to be pre-test training from a qualified instructor followed by some post-test training. However, when accident-involvement as a function of pre- and post-test training were compared taking experience and exposure into account, no significant differences were found, and annual mileage was found to account for the largest amount of variance (5%).

The effect of the differing types of novice driver training and also of additional, post-test training on scores on the twelve metavariables and additional descriptive variables used throughout this chapter were tested using discriminant function analyses. The former solution produced a linear combination of predictor variables that was able to account for a total of over a third of the overall variance, and the number of correctly-classified cases was found to be in excess of that expected by chance. Of the individual predictor variables, those trained mainly by a friend or relative could most easily be distinguished by their driving exposure, having considerably more than those trained by either a qualified instructor or a combination of the two types. Those drivers mainly trained by a qualified instructor were also found to believe themselves more likely to become involved in an accident than the average driver.

The second discriminant analysis, which produced an excellent solution, showed that drivers who had received some advanced training reported better attendance to vehicles in front and more patience, were more likely to pay special attention to vulnerable road users at junctions, and were more likely to drive as part of their work.

8.10: SUMMARY OF CHAPTER 8

Just under 30% of the questionnaires sent out were returned containing useable data. The age and sex distributions of respondents were not found to differ significantly from that of the known driving population and it was concluded that the received sample was representative of that population. Respondents from the police accident records sample (PAR) provided the most diverse responses, including a significantly higher proportion of them driving as part of their work. They were also found to have taken more driving tests and lessons, although only the former difference was found to be significant.

In Section 2 of the questionnaire, respondents described 383 accidents, in which over a third were deemed to be the 'victims' of the accident. More accidents occurred at T-junctions than any other location, and over 90% of respondents were driving cars at the time. Almost half of the respondents did not report using any form of accident-avoidance measure, and over half felt that there was nothing they could have done to prevent the accident from occurring, although under a third felt that this was true of another party. In almost two-thirds of the cases, the independent raters and the respondents agreed on the issue of accident culpability.

The principal components analyses were generally successful, the factors accounting for over 50% of the variance in all but one case. Interpretation of many of these factors was reasonably straightforward (eg. DESCFAC2), but others were slightly more confusing (eg. REPOFAC1). Reliability tests were performed on the scales computed from these factors, with 60% producing reliability coefficients in excess of 0.6.

These reliable metavariables were used in addition to a number of descriptive items for a series of multivariate analyses performed to identify factors associated with various aspects of accident-involvement. Accident liability was the first analysis receiving this treatment and the multiple regression analysis showed that driving experience and the sex of the respondent were the best predictors of accident-involvement, although more accident-liable drivers were found to describe themselves as being more self-centred/ill-mannered. A similar analysis concerning junction-only accidents was not as satisfactory, although the more junction accident-liable drivers were found to describe themselves as more self-centred/ill-mannered and careful/attentive were also generally older.

A discriminant function analysis was performed to discriminate between drivers deemed to be either culpable or non-culpable for the described accident according to independent raters. Culpable drivers were found to be distinguishable by their reported worse attendance to vehicles in front and impatience, along with a reduced belief that careless junction approach styles will result in an accident. They also felt that they were more likely to become involved in an accident during the subsequent twelve months than the average driver. In a separate analysis, those respondents who denied accident culpability in conflict with the raters' assessment were found to describe themselves as being less self-centred and/or ill-mannered and also reported being better attenders to vehicles in front and more patient.

The respondents' use of accident avoidance techniques and also their sense of helplessness in the accident described in detail were investigated. The former analysis did not prove to be particularly satisfactory, although it did reveal that drivers who did not adopt some form of avoidance measure were more likely to have been trained by a qualified instructor. Additionally, those drivers who felt that there was something they could have done to prevent the accident were likely to describe themselves as more negligent and were also found to be more likely to have received some form of advanced driving tuition. In addition, those drivers who admitted culpability for their accident were also found to be significantly more likely to feel that there was something they could have done to prevent it.

The differences between the three main categories of accident identified in Study 1 (rear-end shunts, left-turns and cross-traffic) were the focus of Section 8.7. Those respondents involved in rear-end shunts felt that the other party was powerless to prevent the accident on more occasions than they felt they were themselves. Drivers involved in left-turn and cross-traffic accidents felt that the other party could have prevented the accident by driving more slowly more often than they could have themselves, but also felt that they should have been more observant more than other parties.

A pair of discriminant function analysis was performed to discriminate between 'rear-end shunt' drivers and non-accident-involved drivers and also between a combination of 'left-turn' and 'cross-traffic' drivers and non-accident-involvees. These two analyses produced similar, but relatively poor, solutions. Male drivers and those believing that careless junction approach practices will result in an accident were over-represented in both accident classes. The rear-end accident-involved drivers reported an increased belief that driver-centred factors would increase their future accident-involvement chances, whilst the left-turn/cross-traffic accident-involvees were found to report being worse attenders to vehicles in front and being more impatient.

The most effective non-descriptive discriminating variable in many of these analyses was that recording a self-centred and ill-mannered driving style self-description. The ability of a variety of descriptive variables to predict scores on this metavariable was assessed using a multiple regression analysis. Those with higher scores, and therefore with more self-centred/ill-mannered self-perceptions, were found to be younger, to have been involved in more accidents and to be more likely to be male.

Finally, the issue of driver training was studied, with particular reference to the mileage-to-accident records of drivers who received all combinations of pre- and post-test training measured. If no advanced training was taken, the best ratio was found for those whose pre-test training was received mainly from a friend or relative, although the 'safest' combination was found to be pre-test training from a qualified instructor followed by some form of advanced training. However, when experience and exposure effects were eliminated, no significant differences in accident-involvement between any of the combinations of pre- and post-test training were found.

The three types of pre-test training were also used as the dependent variable in a DFA. Those trained mainly by a friend or relative were found to be more easily distinguishable by their increased driving exposure, whilst those trained by a qualified instructor were found to feel that their accident-involvement chances were greater than for the average driver. In addition, a separate analysis predicting receipt of advanced training showed that those respondents who had received some form of advanced training claimed to be better attenders to vehicles in front, to be more patient and better attenders of vulnerable road users.

CHAPTER 9:

DISCUSSION OF RESULTS FOR STUDY 2

9.0: OVERVIEW

The aim of this chapter is to discuss the main findings and methodological considerations from the questionnaire survey. The implications of this for the findings of the observation study and the literature will be discussed separately in the final chapter. Section 9.1 covers the major methodological considerations that emerged from this study, including discussion of the representativeness of the obtained sample, and also briefly suggests some additional analyses which were not included due to lack of space.

The next section (9.2) deals with the main descriptive statistics concerning general and accident-specific details. A large proportion of the analyses described in the previous chapter used metavariables derived from principal components analyses, and it was felt that a brief discussion of each of these was justified (Section 9.3). This is followed (in Section 9.4) by a discussion of the central analyses concerning accident-involvement in general and at junctions, accident culpability, and admissions of culpability. Section 9.5 covers the analyses concerning the adoption of accident avoidance measures and accident-involved drivers' feelings of accident preventability in their described accidents.

Issues concerning the main accident forms uncovered in the observation study were also subjected to investigation, and these are discussed in Section 9.6. The following section (9.7) focuses upon discussion of the metavariable which was found to be highly prominent in many of the analyses in Chapter 8, the self-descriptor measuring degrees of self-centredness and aggression. One of the major concerns of this study was the role which driver training plays in behaviour formation and how it may be used to improve driving, and the questionnaire analyses concerned with training issues are discussed in Section 9.8. Finally, the main points from each of these sections are summarised in Section 9.9.

9.1: DISCUSSION OF METHODOLOGY FOR QUESTIONNAIRE STUDY

9.1.1 Questionnaire Returns

Prior to discussing the main points concerned with the methodology adopted for the second stage of the research, it is worth reflecting on the representativeness of the received sample so that the results discussed in this chapter may be placed in context. The proportion of questionnaires returned was lower than expectation, and the fact that under 30% of those sent out (and presumably received by the intended recipient) were returned and contained useable information suggests that many of the potential respondents were discouraged by some aspect of the questionnaire itself.

Perhaps the main concern was over the overall fifteen to twenty minute completion time, some respondents, particularly those involved in an accident (and therefore required to complete Section 2), reported that it was too long. However, it should be noted that the lowest return rate was obtained in the PAR (police accident records) sample. It is very likely that, despite the covering letter from the Chief Inspector, the issue of their personal and accident details was somewhat contentious and many may have objected to the confidentiality of these details being, to some degree, breached. Indeed, a number of people from all samples did telephone to express concern over the source of their personal details, although all appeared to be reassured by the responses given. It is possible that the very nature of accident-involvement discouraged a number of potential respondents, perhaps distrusting the stated aim of the research and fearing insurance company or police 'snooping'. Additionally, some people may have been unwilling to unearth long-forgotten, and possibly traumatic, memories of an accident.

Whatever the reasons for the relatively low number of questionnaires returned, it was shown (see Section 8.1.2) that the whole sample could not be said to have a similar distribution to that of the national driving population in terms of age and sex. However, when the potentially distorting effects of the PAR sample were taken into account, the sample obtained from the DVLA records was found to be equivalent to the national figures on these criteria. The slight differences, such as the over-representation of younger female drivers, suggests that the analyses described in Chapter 8 would have been more representative if case selection had been performed using a quota sampling technique. However, the lower numbers of cases in some sub-groups in several analyses meant that this would almost certainly have violated such considerations as case-to-variable ratios. In addition, it can be argued that, with a survey of this nature, one can never be certain of the true representativeness of the received sample, even if it appears to match the population on all measured parameters. It is possible that the non-responders differ from the responders in some crucial manner, and it is therefore suggested that analyses such as those described in the previous chapter should only serve as guidelines rather than be treated as definitive.

9.1.2 Utility of Questionnaire Method in this Study

It should be evident that to have obtained an equivalent amount of information from 740 drivers by a method other than that of the questionnaire survey would have been extremely expensive, both in temporal and financial terms. However, it can never be certain that the information provided is correct when this method is adopted. Indeed, 25.0% of drivers from the PAR sample who reported a single-accident within the time period covered by the sample of accident-involved drivers (ie. for which it can be certain that the described accident was the one for which their name appeared in the accident records) reported that neither the police nor insurance company had deemed them to be the responsible party. Perhaps even more revealing was the fact that 6.3% claimed that there was no police or insurance company involvement in their reported accident. Despite this, it is felt that the majority of responses, particularly on the items other than the accident details, are likely to reflect the respondents' true beliefs at the time of completion.

In an ideal situation, it would have been preferable to supplement the questionnaire responses from each person with additional data, particularly concerned with actual driving style. In addition, the study of the cross-traffic and left-turn accidents may benefit from investigation of judgemental lapses. Indeed, it would be useful to be in a position to use judgemental data, possibly obtained from laboratory studies, to use in conjunction with questionnaire and real driving items. However, the practical implications of performing this kind of multi-format study on a large enough group of respondents to produce reliable results for each general accident type are likely to be immense.

With the resources available, it is believed that the questionnaire study was sufficiently able to provide vital clues towards an understanding of junction accident-involvement, and that, despite its shortcomings, the data produced results that are likely to be suitably reliable to enable further studies to be based upon them.

9.1.3 Adequacy of Accident Details Recorded

One of the main concerns with questionnaire design is the phrasing of the individual items, and the problems caused by an inappropriately-worded question were highlighted by some responses to the item requiring the respondents to provide *brief* details of their most recent accident. Despite the fact that four lines were clearly available for their descriptions, some respondents chose to take the instruction too literally and provided totally inadequate accident details. It is suggested that the majority of accidents are idiosyncratic in nature, and that a large, and probably impractical, number of items would be needed to obtain a truly accurate picture of each accident. The only way to counteract this within the questionnaire format is to use open-ended items such as those used in this study. If accompanied by an instruction more explicit than that used in this questionnaire, particularly with reference to the level of information required, the majority of responses should provide enough information for an accurate analysis of each accident to be made. It is felt that this is particularly important if the information is used as the basis for making culpability assessments.

It could be argued that it would be more profitable to use totally open-ended items, possibly just a single item, due to the unique qualities likely to be shown by each accident. However, this is likely to produce extremely vague responses from some drivers, and it is felt that at least the use of some closed items ensures that a certain amount of useful information about the accidents is obtained. It should also be pointed out that the other major problem with this reliance upon the accident-involved drivers to provide the accident information is that the report is less likely to be impartial than if the details were obtained from an independent source, or variety of sources. However, it is the practical implications of contacting other involved parties that prevent serious suggestion of this technique. It should also be noted that the use of police accident records is often impractical as it requires police participation, and it is the direct experience of the author that, for whatever reason, these reports are occasionally at least as inadequate as those provided by the respondents to this questionnaire.

Perhaps the most appropriate technique of obtaining information about accidents is that of direct interview, as it allows the interviewer to improvise questions and follow paths that may not be revealed by the questionnaire method. Although it is unlikely that this technique could be used to record information about a similar number of accidents as covered by this study, the information gained from a smaller number could be used to develop more appropriate items for specific accident types.

9.1.4 Utility of Non-Accident Items

Although the first section of the questionnaire was probably too long, most of the items in the remaining sections were put to good use. The items contained in Section 3 (the likelihood of a number of behaviours resulting in an accident) produced strong factors, but it is felt that the section could have been improved. In particular, it would perhaps have been even more useful if an example to use as a 'yardstick' had been provided, so that respondents' estimates could have been compared with actual accident likelihoods derived from accident records.

As pointed out in a subsequent section (9.3), the reported behaviour items did not function as required, and it is felt that the rather random nature of their selection, and of those items included in Section 5 of the questionnaire, contributed to the fact that only a small number had any practical application. If more time had been available, it is suggested that more extensive piloting of these items would have been carried out and those shown to have no practical purpose discarded. However, the scales that were found to display reliability proved to be most useful and it is suggested that they may be of use to researchers investigating similar issues.

The value of this relatively small number of reliable metavariables to the analyses demonstrates the likelihood that a larger set, comprising metavariables describing a wider range of phenomena connected with driving at junctions, would be of considerable practical use. It is therefore highly recommended that future studies should aim to uncover these, perhaps to be used in conjunction with the reliable metavariables used in the current study.

9.1.5 Assessment of Sampling Technique

The fact that the obtained sample was not shown to significantly differ from the population in terms of age and sex suggests that the sampling strategy was able to produce a truly representative cross-section of British drivers. However, doubts concerning the database supplied by TRRL should be expressed considering that over 6% of questionnaires were returned due to insufficient or out-dated information. It is argued that the implications of this for the findings of the research are reduced by the probability that these inadequate addresses were randomly distributed across all age/sex sub-groups.

It would have been preferable to rely upon the general database for all the information collected, but well over a third of the described accidents were from respondents in the PAR sample, and omission of that sample would almost certainly have meant that insufficient cases would have been available for several of the analyses described in the previous chapter. Of course, this could have been overcome by using a larger general sample, but it is argued that this lacks efficiency due to the relatively high ratio of non-accident-involved drivers that would be received - far more than would be necessary for the analyses. Assuming that the PAR sample is representative of all accident-involved drivers (although evidence from Section 8.2.3 revealed that Milton Keynes is not representative in terms of accident locations) there is no reason why this method cannot be used to create an 'artificially large' accident-involved sample.

9.1.6 Suggested Additional Analyses

Due to space restrictions, the previous chapter was only able to describe a small proportion of the possible analyses of interest with the data obtained from the questionnaire returns. In particular, there were many individual variables that may have proved to be effective discriminators between certain sub-groups, but which were not used due to their failure to become included in a reliable metavariable. For example, it would have been interesting to investigate the ways in which responses to items such as "I sometimes don't see motorcycles until it's almost too late" relate to demographics, accident-involvement and to other aspects of driving at junctions. In addition, several respondents described accidents involving motorcyclists and pedal cyclists, and it would be useful to be able to perform analyses on this issue. The number of variables contained within the questionnaire mean that the total number of potential analyses was huge, and a large degree of selectivity had to be employed. Those that were selected for inclusion were deemed to be central to the main objectives of the research, but it is not claimed that they form a comprehensive guide to the area, and there is clearly much scope for further analyses.

9.2: DISCUSSION OF GENERAL DESCRIPTIVE STATISTICS

9.2.1 General Descriptive Statistics

The most notable aspect of the brief analysis of basic descriptive information were the differences between the sample obtained from the Thames Valley Police accident records (PAR) and the remaining two. These former drivers were found to have a significantly higher annual mileage and were also found to have taken more driving lessons, driven for fewer years on a regular basis and taken the driving test more times (although these latter tests were non-significant). A lower proportion of them were also found to be car licence holders, primarily car drivers and a significantly higher proportion drove as part of their work.

These differences appear to suggest that the sample derived from police accident records should have been treated separately from the other samples in subsequent analyses. However, it is suggested that many of these discrepancies may be connected with the known major difference between the samples - accident-involvement. It may be remembered that the main purpose of obtaining a separate purely accident-involved sample was to ensure sufficient numbers of the sub-groups of interest were available for the analyses. The higher proportion of accident-involved drivers in this sample would clearly manifest itself in ways other than in the total accident count, and it was the intention of the analyses to uncover these aspects of driving.

9.2.2 Descriptive Statistics for Accident Items

Although the PAR sample had the highest proportion of drivers involved in all accidents (88.1%) and accidents at junctions (86.1%), it is surprising that the figure was not 100% given the selection criteria for this sample. One possibility is that drivers in this sample were unwilling to admit to their involvement in an accident. However, the fact that they bothered to return the questionnaire suggests that it is more likely that the damage limit of £100 served to exclude accident descriptions from many of the remaining 12% from the PAR sample. This limit was set so as to exclude detailed descriptions of minor accidents and allow the study to focus upon those of a more serious nature. Unfortunately, there was little or no information contained with the police accident reports pertaining to amounts of damage caused, so those involved in 'minor' accidents could not have been excluded at this stage.

The largest proportion (36%) of the accident descriptions concerned situations in which another vehicle had hit the respondent's vehicle, implying guilt on behalf of the 'other party'. A similar proportion of accidents (40%) resulted from the reverse situation, in which the respondent ran into another vehicle. The remaining cases involved situations in which the respondent ran into an obstruction or for which sufficient details were not made available. If a reasonable cross-section of accident-involved drivers had been sampled, it might be expected that there would be a corresponding number of drivers belonging to the first two mentioned groups. However, the PAR respondents were selected on the basis of the police attribution of their guilt, and it is therefore not surprising that there was found to be a higher proportion of respondents who described running into another vehicle. The major forms of accident were found to correspond to those highlighted in Study 1: left-turn (5.5%); cross-traffic (11.2%); and rear-end shunts (18.8%). In terms of format, right turn accidents have some similarities with left-turn and cross-traffic accidents, but only a couple of examples were recorded and, on this basis, this manoeuvre can not be thought of as a major source of accidents for the sample.

This study was intended to concentrate upon accidents at junctions, and once the non-junction accidents had been accounted for, almost 300 occurring at junctions were available for analysis. In concordance with the Department of Transport's (1990) statistics (see Section 1.1.3), T-junctions were found to be the most common source of these accidents, not surprising given the predominance of this type of junction. However, this study recorded a higher proportion of accidents at roundabouts and fewer at T-junctions and crossroads than the national figures suggest. Almost certainly the main reason for this is the fact that two of the three samples were centred on Milton Keynes, a city highly dependent upon roundabouts in its' road network. Not surprisingly, the vast majority (88.5%) of the accident describers were driving cars at the time of their accident, probably more of a reflection on the predominance of that form of vehicle in general than anything else.

The accident avoidance techniques and the reasons for their selection were briefly investigated. The most common form of avoidance adopted was braking, although over 40% of respondents did not adopt any at all. The question asking for the reasons for respondents' selection of avoidance measures produced a small range of responses mainly covering the more general possibilities such as 'best option', 'automatic response' and 'panic'. However, the responses to the suggested accident prevention measures items were more revealing. In agreement with the literature (eg. Clay, 1987), respondents were found to have a tendency to attribute blame onto another party by claiming that there was nothing they could have done to prevent the accident on more occasions than they felt the other party was similarly powerless. This supports the notion (eg. Hogarth, 1987) that people have a tendency to attribute favourable outcomes to personal factors whilst blaming situational factors for unfavourable outcomes. The over-representation of supposedly 'guilty' drivers (by virtue of the PAR sample), suggests that this effect is probably more marked than it at first appears to be. However, it is unlikely that much can be learned about accidents at junctions by combining all accident types, and it would be more worthwhile to discuss these avoidance and prevention measures in relation to specific accident forms. Analyses relating to the main accident types were described in Section 8.7, and these will be discussed in a later part of this chapter (Section 9.6).

This unwillingness to accept responsibility was reinforced by the responses to the individual accident attribution items, in which it appeared that under a third of people were willing to ascribe the main portion of the blame onto themselves, although just over a third were prepared to accept partial responsibility. The most popular choice for these attributions was another driver, but respondents also displayed a tendency to implicate external factors such as road and weather conditions, poor visibility and poor road design.

In recognition of the possibility that some drivers may underestimate their own role in the causation of an accident, the respondents' assessments of this role in relation to that of other road users was compared with that made by an independent team of raters. The main drawback with this technique was that the latter assessments were made on the basis of the accident descriptions provided by the respondents, which in some cases were highly inadequate. As the limited amount of available space meant that truly extensive descriptions could not be recorded, there must remain some ambiguity even with the most detailed descriptions provided. Additionally, it is likely that respondents may not have consistently provided the level of detail necessary for such reliable assessments to be made, even if sufficient space had been provided. Indeed, there is evidence to suggest that some of the raters' attributions may be mis-classed, as there were four examples in which the respondent claimed responsibility in direct contrast to the decision reached by these raters. It is unlikely that a driver would admit to causing an accident that was mainly due to the driving of another road user, and it is felt that these examples, although small in number, point to inadequacies in either the descriptions or the rating system.

Despite these shortcomings, it is argued that in the majority of circumstances, attributions of blame could be accurately derived from the accident descriptions, regardless of the complexity of the circumstances and in the absence of details of the full range of contributory factors. Taking the 'rear-end shunt' type of accident as an example, it is maintained that the following driver will usually be at fault in such circumstances. These drivers may choose to blame indecision or sudden braking by the driver in front. Nevertheless, it is felt that, ultimately, the collision would not have occurred had the following driver adopted a reasonable following distance and speed and also paid sufficient attention to the vehicle in front without assuming anything about the latter driver's intentions. Although fewer in number, some of the accidents described were more ambiguous, but it is likely that the majority of descriptions were sufficient enough to allow a reasonable judgement of accident culpability to be made. However, it is worth noting that provision of a sufficient quantity of information does not necessarily ensure that the necessary quality of accurate information is achieved.

The assessments of accident culpability produced agreement between the respondents and the raters in almost two-thirds of examples, but it interesting to note that a relatively high number (57 - 17.5%) of respondents whom the raters felt were culpable claimed to be 'victims'. The differences between these 'admitters' and 'deniers' were investigated and will be discussed in a subsequent section (9.4.3). However, it should be noted at this point that it is possible that some or all of these respondents were correct in their assignments of culpability and it is simply either the inadequacy of their accident descriptions or incorrect assessments by the raters that lead to this disagreement. However, given the nature of the majority of these accidents, it is likely that such cases, if they exist, will represent the minority.

9.3: DISCUSSION OF PRINCIPAL COMPONENTS ANALYSES AND CONSTRUCTION OF SCALES

9.3.1 Undesirable Driving Practice Items

The items from Section 3 of the questionnaire, for which respondents had to indicate how likely they felt each type of behaviour described would result in an accident, reduced to four reasonably clear and reliable factors. However, it is interesting to note the two variables which failed to gain inclusion in any of the metavariables. The first ('Drivers not indicating correctly') is significant in light of the fact that a similar item originally included in Section 5 of the questionnaire was not included in the final version due to a complete lack of variance displayed in responses to the pilot study. However, analysis of Table CC.5 in Appendix CC shows that this variable obtained a factor loading score of 0.44 for Factor 1, dealing with careless or egocentric junction approach styles. Careless signalling is consistent with the theme of this factor, and the exclusion of this seemingly important variable from any of the factors is perhaps more a consequence of the criterion selected rather than of the usefulness of the individual variable. Indeed, the same can be shown to be true of the other 'missing' variable ('Drivers behaving aggressively') which narrowly missed inclusion into Factor 2 ('Careless junction negotiation').

9.3.2 Self-Descriptor Items

The driving style self-descriptor items contained within Section 4 of the questionnaire differed from those in other sections in that previous work has been carried out using these items. The most recent paper, by Guppy, Wilson and Perry (1990), reports two studies in which the responses to the eighteen bi-polar items were subjected to a principal components analysis. Both studies produced four factors and displayed some degree of similarity, with the first factor in each case being labelled 'self-centred/ill-mannered' and comprising essentially the same subset of variables that constitute the factor of the same description in this study.

However, there was less agreement for the other factors, although the overall themes were reasonably similar. The second and third factors produced by this study were also highly interpretable and appeared to bear some similarity to factors from the studies cited by Guppy et. al. In particular, Factor 2 from these authors' first study (labelled 'timid and negligent') combines elements from DESCFAC2 ('negligent') and DESCFAC3 ('timid') of this study, whilst DESCFAC3 bears some resemblance to Factor 2 ('nervous and indecisive') from the second, confirmatory, study.

Despite the obvious similarities between the factor structures of these independent analyses, there are clear differences which should not be apparent if the scales are valid across all samples. However, it should be noted that the two studies quoted by Guppy et. al. comprised data from 42 and 188 respondents respectively and it is suggested that the factors produced by the current study, with well over 700 respondents replying to each item, will be more reliable. For example, the second study reported by Guppy et al. showed that 52% of respondents were male whereas the sample of males for the current study was 59%, considerably closer to the national figure of 61% (see Table 8.2). In the current study, the reliability estimates obtained for each of the metavariables derived from the factors displayed relatively high degrees of reliability (all alpha values in excess of 0.7) and the results of this analysis can be thought of as providing further evidence that there are a small number of self-descriptive components for drivers that show some degree of reliability over time and alternative samples.

Finally, it is of interest to note that the self-centred and ill-mannered construct emerged as a separate factor from that measuring timidity. It might have been anticipated that a non-self-centred/ill-mannered driver could be considered to be timid, but the fact that these concepts emerged on independent factors rather than being the poles of one factor suggests that the two scales are measuring entirely distinct phenomena.

9.3.3 Opinion Items

The twenty-five opinion statements contained in Section 5 of the questionnaire were derived from a variety of sources and it is therefore not surprising that there was little evidence of cohesiveness within the set of items. However, the first two factors were quite easily interpretable and produced high reliability coefficients. Other factors, such as OPINFAC3 ('Assertiveness at junctions') and OPINFAC4 ('Conformity'), appeared to contain variables displaying a consistent theme, although they proved to lack suitable reliability. Three of the remaining four factors were single-variable factors and were therefore omitted from further analyses. Factors such as these clearly describe important aspects of driving at junctions, and it should be noted that the lack of reliability of such factors may be more a result of inappropriate phrasing of the initial items.

9.3.4 Reported Behaviour Items

The reported behaviour questions were derived from the same sources as those discussed in the previous section, and it is felt that the same problems may apply to these items. The twelve variables were essentially divisible into two groups of six, each of which was designed to cover many aspects of each of junction approach and junction entry behaviours. The fact that the analysis did not produce any reliable and interpretable factors tends to suggest that the initial variables were not sufficiently able to cover these aspects of junction negotiation.

The only reliable metavariable appeared to be composed of two main elements (attendance to vehicles in front and impatience) and its' prominence in several subsequent analyses often made interpretation of these analyses difficult, creating uncertainty as to which of the two elements, or even if both, contributed to the effect. An additional PCA was performed on these six items in isolation to determine whether the presence of the other six variables confounded the issue and prevented a more interpretable split. However, only a single factor, onto which all six variables loaded, was produced in this subsequent analysis, suggesting that the two components of driving at junctions are inextricably linked. Indeed, it might be expected that drivers who are prone to impatience will, by definition, be keen to enter the junction and they may forfeit some aspects of the task, such as spending time watching the progress of vehicles in front. Alternatively, it may be more appropriate to view these two aspects of junction negotiation as being manifestations of a more general 'carelessness' factor, which neither of the other principal components emerging from this variable set covered. Therefore, the strong association between inattention and impatience in this case may be a function of this more general concept.

However, the issue would appear to be confused by the way in which certain questions were stated, relying on conditional components rather than asking for reports on 'pure' behaviours. For example, the final item requested respondents to state to what extent they agreed with the following statement: "When queuing up to enter a junction, I often find myself almost colliding with the vehicle in front because I had expected it to have moved.". A driver who did indeed often almost collide with vehicle in front when queuing to enter a junction, but for an alternative reason, would be forced to 'disagree' with this statement, despite participating in the activity the item was designed to measure. Although some additional related items were included, the number of suitable alternative options available was still limited, and it is possible that many important reasons behind behaviours such as close following and pulling out at junctions were not covered. Despite being a less than optimal measure of reported behaviours, it is suggested that many of the items, including the single metavariable retained for the further analyses, are useful when treated as opinion statements, and therefore are best thought of as supplements to the Section 5 questions.

9.3.5 Increased Probability of Accident Involvement Items

The final set of items to which the PCA technique was applied were those designed to measure the elements which respondents felt would increase their likelihood of becoming involved in an accident at a junction, being derived from an open-ended question used at the pilot stage of the questionnaire. As with the previous set of questions, they were designed to fall into two distinct groups. On this occasion, the division was perfect, with no variables failing to gain a high loading score on a factor. The primary factor was concerned with the effect of external or environmental aspects of driving on accident-involvement, and can be thought of as having similarities with UDPFAC4. However, the latter factor measured the probability of certain elements *generally* resulting in an accident, whereas INCPFAC1 concerned the effect on the individual's chances of accident involvement.

9.3.6 Selection of Metavariables for Subsequent Analyses

It would clearly have been counter-productive to include the full set of metavariables in subsequent analyses and some form of selection criteria had to be adopted. Selection on the basis of reliability of scales appeared to form the most appropriate basis as it is obviously desirable that the results, and therefore the independent variables used to obtain those results, are as reliable as possible. However, it is clear that the omission of some factors left an incomplete guide to driving at junctions. For example, the opinion expressed by OPINFAC5, which reflects a belief in a superior driving style, is known to be possessed by a certain proportion of drivers (eg. Svenson, 1981), but due to the items measuring this trait being unable to achieve a satisfactory reliability score, the metavariable was excluded from subsequent analyses. Once again, this may be a reflection of the original items' phrasing or recognition of the possibility that the opinion can be best expressed in a single statement.

Despite the strong possibility that many aspects of driving at junctions may not be covered by the metavariables included in the main analyses (and may not have been included on the questionnaire at all), it is argued that those which were included covered a wide range of expressed beliefs and other details. Indeed, it is worth noting that all metavariables bar UDPFAC3 ('Reckless driving') emerged as good predictors in at least one analysis reported in Chapter 8. The fact that the analyses covered a wide range of phenomena associated with driving at junctions suggests that the metavariables may have covered a reasonably comprehensive range of relevant attitudes and perceptions concerned with this matter and were therefore of great practical use in the determination of factors implicated in accident-involvement at junctions.

9.4: ACCIDENT LIABILITY & CULPABILITY

9.4.1 Accident Involvement at all Locations

The first analysis incorporating the metavariables derived from the principal components analyses investigated the matter of differential accident involvement following Grayson and Maycock's (1988) suggestion that road safety research should concentrate upon the issue of accident liability (see Section 6.4.1). In the same section, a study conducted by Harano, Peck and McBride (1975), in which a variety of personal descriptive information in conjunction with performance scores on psychometric tests were used to predict accident liability, was briefly discussed. It was felt that this approach could be modified to satisfy the requirements of the research cited here and all of the major subsequent analyses in described Chapter 8 were designed to investigate various phenomena using a combination of descriptive information and that concerning attitudes, reported behaviours and perceptions about driving at junctions.

The analysis concerned with all accidents regardless of their location was extremely revealing and accounted for a relatively large proportion of the overall variance in accident counts. However, the regression equation produced in the previously cited study by Harano et al. accounted for 40% of the variance (adjusted $R^2=0.400$) in comparison to the 16.8% achieved by the current study. Whilst this initially appears to suggest that the former study was more successful than the latter, it should be noted that the solution reported by Harano et al. was based upon a small sample size with a case-to-variable ratio of 7.6:1 in comparison to the 15:1 for the current study.

An additional source of concern over the Harano et al. study is that these researchers merely distinguished between drivers with no accidents and drivers with any number of accidents. Therefore, the regression equation was used to predict either involvement or non-involvement in accidents and it is clear that this technique does not fully utilise the maximum amount of potential information available. For example, it might be expected that a driver who has been involved in just a single accident over their entire driving history will differ from a driver who has been involved in ten accidents during the same period of time. By adopting the Harano et al. technique, both drivers would be included in the same group and it may be that there exist greater differences between these two drivers than between the single-accident-involved driver and one who has never been involved in an accident. In this respect, it is more appropriate to distinguish between all levels of accident liability as adopted in the analysis reported in Section 8.4.1.

However, rather than treating these two studies as directly opposing, it would be more profitable to investigate how well a combination of the approaches could predict accident liability. Assuming that the variance accounted for by each study is a true reflection for the relevant population, the two studies together account for almost 60% of the variance in accident counts and although there will certainly be a degree of variance shared by the two variable sets, the true figure may be as high as 50%. Of course, this is purely hypothetical, and it would necessitate a large-scale research project concentrating upon all aspects of driving covered by these two studies to investigate the matter, but the possibilities of combining such sources of information should be noted.

The contributions of the individual variables to the equation produced from the analysis reported in Section 8.4.1 should be discussed. Researchers (eg. Brown, 1982) have previously expressed concern over the confounding influence of exposure (in terms of both intensity and duration of exposure) factors in the study of accident involvement and this analysis provided a means by which such factors could be controlled for. Certainly, the emergence of the two variables effectively measuring duration and intensity of exposure (YEARSDR and MILES) as good predictors should be no surprise. Indeed, common sense dictates that the more driving situations, and therefore encounters with other road users, a driver presents him/herself with, the more likely they are to become involved in an accident. An additional factor that emerged from this analysis was the strong predictive ability of sex, with male drivers being positively related to higher accident involvement. This also confirms previous research as authors such as Foldvary (1979) have noted the over-representation of male drivers in accidents when mileage factors have been controlled for.

Perhaps the most notable aspect of this analysis was the predictive ability of one the self-descriptive metavariables, DESCFAC1. The fact that this metavariable was retained in the final solution when sex and exposure factors had been accounted for indicates that it is able to account for variance in accident rates not accounted for by those established accident-related factors. In fact, when judged by the magnitude of the beta weights, this variable was the most effective predictor of accident-involvement after the duration of exposure variable. If it is assumed that drivers scoring more highly on this metavariable are indeed more self-centred and ill-mannered, it follows that they will be generally less attentive to other drivers and the driving environment. Additionally, they may be more prepared to assert themselves and it seems logical that these factors should serve to place such drivers at an increased level of risk of becoming involved in a collision. Previous research by Guppy, Wilson and Perry (1990) using the identical set of eighteen bi-polar variables from which DESCFAC1 was derived also found that a similar metavariable (see Section 9.3.2) was significantly correlated with accident involvement when experience was controlled for. However, it is suggested that the current findings are even more compelling given that the sample size was considerably higher and that a far wider range of factors were controlled for. In terms of corrective programmes, it would clearly be of considerable use to ascertain how these self-centred and ill-mannered drivers develop and this will be dealt with in Section 9.7.

Several additional variables were found to be good predictors of accident liability and it is felt that a brief discussion of these is warranted. It is perhaps understandable that those drivers who have been more highly accident-involved should rate their chances of future accident involvement more highly than those who have been less accident-involved. Rather than assuming that these drivers' higher level of liability is at least partly a function of this belief, it is far more likely that the reverse is true and that this assessment of future accident-involvement is based upon their previous accident experience. It was also found that drivers who reported mainly driving a vehicle owned by someone other than themselves or a friend or relative were more accident-liable. It may be that such drivers are likely to take less care over their driving because they are less likely to be responsible for the financial and other consequences of an accident. The majority of these respondents will be company car drivers whose employers take responsibility for the vast majority of repair costs and insurance claims and it is possible that this situation would radically change should these drivers be made fully accountable for all consequences of their actions.

9.4.2 Accident Involvement at Junctions

It might have been expected that the analysis designed to predict accident involvement at junctions only, using an identical set of predictor variables, would produce similar results to the analysis for all accidents. Such similarity would imply that the factors associated with junction accidents are identical with those for accidents in general. Indeed, the results proved to be very similar, with roughly equivalent proportions of variance accounted for and having five common strong predictors. Sex of the respondent and the extent of their intensity and duration of driving exposure emerged as good predictors of junction accident involvement. It is also of significance that drivers who had been involved in more accidents at junctions tended to describe themselves as self-centred and ill-mannered.

This suggests that there are no major differences between the factors implicated in accident involvement in general and at junctions. However, it should be noted that a high proportion (75.5%) of respondents who reported being accident-involved were also junction-accident-involved. It should not be too surprising, therefore, that the results of the two analyses are extremely similar and it may be of more interest to investigate the nature of the differences, however slight. Perhaps the most obvious difference was the absence of the predictive ability of the variable measuring vehicle ownership in the junction-only analysis. Although this appears to a major discrepancy at first, it should be noted that the variable DRWORK, which emerged as a predictor at the first stage of the latter analysis, measures a very similar phenomenon (whether the respondent reported driving as part of their work) and inspection of the correlation matrix in Appendix DD reveals that the bivariate correlation between these variables was 0.377 (14.2% variance accounted for). It can therefore be argued that the analyses do not differ in this respect and the points raised in the previous section about this matter are relevant here.

The other major difference was the absence of the variable measuring the respondents' assessments of future accident-involvement probabilities in relation to other drivers (PACC) in the junction-only equation. This implies that those people involved in accidents at junctions do not project their previous record onto their assessments of future involvement chances. It is possible that, because there are potentially more points of interaction between drivers at junctions than elsewhere, these drivers tend to feel that the they will only be accident-involved when those particular elements are all present. If they assume that the chances of those elements all appearing simultaneously on another occasion are remote, it follows that they will rate their accident-involvement chances correspondingly. Despite this conjecture, it should be noted that the variable in question here is relatively highly correlated with junction-accident frequency ($r=0.143$, $r^2=0.02$) and that, had the criterion for variable retention been only slightly less conservative, PACC would have been entered into the regression equation at the next stage.

Finally, it is worth mentioning the fact that none of the attitudinal or perceptual metavariables concerned with junction negotiation emerged as effective predictors of accident-involvement. For example, it might have been anticipated that the metavariable measuring the extent to which a driver attends to vehicles in front and their degree of impatience would be a good predictor of accident-involvement at junctions. The fact that this variable, and others measuring similar phenomena, did not prove to be effective predictors implies that basic accident involvement, both at junctions and elsewhere, is much more dependent upon basic demographic factors than upon such attitudinal or perceptual factors. The one exception to this was found to be the self-descriptor DESCFAC1, and this matter will be dealt with later on in this chapter (Section 9.7). Additionally, although the poor predictive power of these items was found for the liability analyses, it proved not to be true when the issue of culpability was investigated and this will be discussed in the next section.

9.4.3 Accident Culpability

One feature of the analyses designed to predict accident-liability discussed in the previous sections is that all accident-involved respondents, regardless of the circumstances under which the accident occurred, were included. However, useful that this may be, it is argued that it is the 'guilty' parties that are of more interest, and the analysis to determine the differences between the accident 'causers' and the 'victims' can be thought of as being the most central to the second study. Despite this, it is recognised that the analyses concerning culpability were based upon single examples of accidents at junctions and it is suggested that it may be of greater benefit to consider drivers who have been repeatedly guilty of causing accidents. Unfortunately, the level of information required for this kind of investigation was beyond the scope of the present study. Additionally, the fact that junction-only accidents were included in the analysis means that the findings can only be discussed in the context of accidents at junctions and the factors contributing to general accident culpability may be different.

Despite minor reservations about the relatively small case-to-variable ratio, the discriminant analysis differentiating between culpable and non-culpable accident-involved drivers proved to be highly successful, accounting for over a third of the variance. One of the most interesting aspects of the particular strong predictors that emerged from this analysis was the dominance of the metavariables created for this study and the absence of some previously identified as being implicated in differential accident-liability. For example, no sex differences were found between the two groups and, despite being retained in the final solution, the predictive ability of driving experience was relatively low. In addition, ownership of the most frequently driven vehicle was identified as a predictor of accident involvement yet no such differences were found in this analysis.

The culpable drivers reported themselves to be worse attenders of vehicles in front and more impatient and were found to view careless and/or egocentric junction approach styles as being less likely to result in an accident. The latter finding lends support to the hypothesis that drivers who rate certain behaviours, junction approach styles in this case, as being less likely to result in a collision will be more likely to behave in that manner themselves. This assumes that there is a positive relationship between beliefs and behaviours and, whilst there remains some doubt about the strength of the relationship between attitudes and behaviours (expressed by Wicker, 1969, for example), the fact that drivers who were judged to be the 'guilty' party in the accidents tended to report displaying this relative complacency towards careless approach styles lends support to the possibility of the existence of this relationship.

The finding that the culpable drivers tended to report being worse attenders of vehicles in front and are more impatient also supports the above assertion, although this assumes that the reporting of these behaviours is accurate. Again, the implication of both factors in accident-involvement appeals to common sense as it is easy to understand how an impatient driver would have a tendency to make rash decisions, and that a basically inattentive driver would tend to place themselves at a greater risk of being involved in a collision. However, a study of this nature can never determine causal relationships between variables. In circumstances such as those described here, it cannot be ascertained whether the culpable drivers were involved in the described accident as a result of holding beliefs such as these or whether these beliefs developed as a direct result of involvement in the accident.

The only way to overcome such difficulties would be to conduct a longitudinal study in which the attitudes and behaviours of a large group of drivers are followed over time. A number of these drivers would naturally be involved in accidents and by re-testing all drivers at a later date, or preferably on several subsequent occasions, the effect of accident-involvement on such attitudes and behaviours could be determined.

It is worth noting at this stage the additional variables that were able to discriminate between the groups. The measurement of relative future accident involvement probabilities (PACC) was found to be a good predictor of both general liability and culpability. The culpable drivers were found to be more likely to report that, when compared to the average driver, they would be involved in an accident during the subsequent twelve month period. Unlike the previous analysis, this is unlikely to simply be a consequence of their previous accident record as both sets of drivers were accident-involved. It is suggested that drivers may have been responding to the two items that made up PACC in terms of future accidents for which they are culpable, rather than just involved. If this was so, it might be expected that the non-culpable drivers would rate their future accident-involvement chances as relatively low due to the fact that they did not cause the reported accident and may assume this lack of culpability would apply to future accidents. Conversely, many of the culpable drivers were found (see Table 8.13) to recognise that they were primarily at fault in the described accident and they may therefore assume that the same is likely to true of any future accidents unless the underlying causes of the accident, whether skill-based, attitudinal or whatever, are corrected.

The only self-descriptor metavariable that emerged as a predictor in this analysis was that measuring the drivers' degree of timidity. It may be remembered that the individual variables contributing to this metavariable described nervous, indecisive, inexperienced and lax driving. That the culpable drivers felt themselves to be more timid suggests that they have a tendency towards hesitation and uncertainty. As driving at junctions often requires that many decisions have to be made in a short space of time, it is clear that a driver who is more nervous and indecisive will sometimes place themselves at risk by failing to accurately communicate their intentions to other drivers. It could be argued that, as drivers in such situations should theoretically drive in a way that anticipates uncertainty on the part of other drivers, both drivers involved in a collision would be culpable. However, it would be impossible to account for all eventualities and, considering the potential number of possible behaviours at a busy junction, it is recognised that some assumptions about the behaviour and intentions of others must be made. Nevertheless, the importance of accurate communication and unambiguous behaviour patterns is clear if confusion, hence the probability of a collision, are to be reduced.

It is also worth discussing a confusing aspect of this issue which emerged from the discriminant analysis. The culpable drivers were found to be more experienced at the time of the accident yet were also younger on average. Given that these two variables were found to be highly positively correlated ($r=0.865$, $p.=0.000$), this apparent paradox may be an indication that the 'victims' generally began driving at a later age than the culpable drivers. If this were so, the reasons why people who begin to drive later on are more likely to be accident 'victims' rather than causers remain obscure.

Perhaps the most interesting aspect of the culpability analysis is how it compares with that looking at accident liability. It has already been noted that predictors of the latter phenomenon tended to be of a more descriptive nature whilst those which were found to predict the former tended to be more attitudinal. However, it is particularly noteworthy that the self-descriptor metavariable found to predict accident liability (DESCFAC1 - self-centred/ill-mannered) was not able to distinguish between culpable drivers and 'victims' when the differences due to other variables had been accounted for.

The implications of these differences for driver behaviour research should be clear, particularly concerning the form of possible corrective programs. Although it is recognised that all accidents are different and that many have complex causal roots, it is argued that in many cases these accidents can be largely attributed to the behaviour of one of the drivers involved. It follows therefore that accident reduction in these cases is dependent upon the removal of the accident-causing behaviours displayed by the culpable drivers. As the analyses discussed in this section suggest, culpability may be more a function of attitudes, beliefs and reported perceptions than of demographic variables, such as exposure and experience, and corrective programs would have to combat these aspects of driving. It is argued that this may be more open to change via educational means than any other, and this issue will be dealt with in greater detail in Chapter 10.

9.4.4 Admissions and Attributions of Culpability

The other main feature of the culpability issue was concerned with the differences between those who admitted and those who denied culpability for accidents deemed by the raters to be the 'fault' of the respondent. It should be noted at this stage that these findings are entirely dependent upon the accuracy of the culpability assessments made by the raters, a problem previously discussed in Section 9.3.

It may be remembered that the culpability deniers were found to describe themselves as generally less self-centred/ill-mannered and also reported themselves to be better at attending to vehicles in front and less impatient. They were also revealed to be more likely to feel that environmental factors influence accident-involvement. The liability analysis discussed in Section 9.4.1 uncovered the tendency for non-accident-involved drivers to describe themselves as less self-centred/ill-mannered, and the dominance of this discriminator in this analysis initially appears to suggest that these deniers may have similar characteristics. Additionally, the fact that deniers reported being more efficient attenders of vehicles in front and more patient implies they share some similarities with non-culpable drivers, who were also found to obtain lower scores on this factor (REPOFAC1).

It is quite possible that these drivers who deny culpability for their accident are being truthful, and their 'guilt' was incorrectly diagnosed due to insufficient accident details or an incorrect assessment of those details by the raters. If this were so, it might be expected that these deniers would share some of the attitudes displayed by accident 'victims'. On the other hand, if it is assumed that the majority of the culpability assessments are accurate, the responses of these drivers may be reflecting a general tendency towards some form of self-deception, whether conscious or not. If it is assumed that they distorted the truth about their role in causing the accident, it not implausible that these respondents may show a tendency to describe their own driving in a similarly distorted fashion in order to reinforce their belief in themselves as a competent driver. Indeed, it is worth noting that there is some evidence of the influence of normative beliefs (see Section 6.1.1) here, as the characteristics displayed by these drivers on the self-descriptor predictors show distinct tendencies towards the 'socially acceptable' ends of the scales. Further evidence for this can be derived from Table DD.12 in Appendix DD. As well as describing themselves as less self-centred and ill-mannered, the culpability deniers also described their driving as less negligent and less timid, despite the fact that neither of these two metavariables were found to be good predictors.

One of the most surprising findings of this analysis was probably the influence of age, with the culpability deniers showing a tendency to be older yet less experienced at the time of the accident. This is a repeat of the situation noted in the previous section, and it appears that again the deniers display similar characteristics to the accident 'victims' who were also found to be older and less experienced at the time of the accident. The previously cited study by Guppy et. al. (1990) reports older drivers as describing themselves in more socially acceptable ways (eg. more experienced, considerate and precise), a phenomenon also found here. This still does not address the reason why older drivers have a tendency to deny causing the described accident. It is possible that younger drivers do not tend to be particularly concerned with having caused an accident, whereas older drivers, especially ones with previously clean accident records, may be more prepared to stretch the truth to enable them to maintain their self-image of being a 'good' driver.

It is also speculated that the data may be confused by company car drivers who tend to be younger than those who drive their own vehicles. Indeed, in this study it was found that the former group had a mean age of 38.34 years against 40.84 for the latter. This difference was found to be significant at the 0.05 level ($t=2.12$ with 256.11 d.f., $p.=0.04$ - using separate variance estimates) although there was found to be virtually no degree of statistical association between these variables (estimated omega-squared=0.005). As employers tend to remove the individual responsibility, in a financial sense, from their drivers, it is speculated that those drivers will be more prepared to admit responsibility than those who would have more to lose on a personal level. Once again, it should be noted that this is purely speculation, and more detailed research would be necessary before further conclusions on this matter could be arrived at.

Finally, the culpability deniers also found to be more likely to report that environmental factors influence accident involvement. This would be consistent with the other findings reported above if these drivers were truly 'not-guilty' of causing the accident. However, if it is assumed that the ratings are accurate assessments of culpability, these drivers appear to be implicating an external locus of control to their actions. In Langer's (1975) terms (see Section 1.7.2), they can be thought of as creating an 'illusion of control' in which they are able to attribute the causes of the accident in a manner that is consistent with their self-image of being a competent driver. This idea also has many similarities with the 'self-serving bias' theory posited by Miller and Ross (1975) (see Section 6.3.1) which states that people have a general tendency to attribute favourable outcomes to personal factors but, as in this case, blame external sources when the outcome is unfavourable. In other words, this culpability denial may be just another manifestation of a more general human trait.

Certainly, the evidence presented here suggests that the culpability deniers tended to share certain characteristics with non-culpable drivers. They also attempt to present themselves in a way that is consistent with this by responding in more self-enhancing manner, such as implicating external factors in accident-causation, in order to retain their self-image as a competent driver.

9.5: ACCIDENT AVOIDANCE & ACCIDENT PREVENTABILITY

9.5.1 Use of Accident Avoidance Measures

Even the most careful and considerate of drivers will invariably encounter situations in which some form of evasive action is required. It will clearly be beneficial to any driver to have the ability to draw upon a wide range of avoidance strategies that they are able to apply to any such situation. The purpose of the analysis outlined in Section 8.6.1 was to determine which factors are associated with reported use of avoidance measures and failure to use such measures. However, it should be noted that in a proportion of the accidents described, the events leading up to it may have occurred so quickly that the respondent had little chance to employ any correctional strategy. It is probably misleading to assume that these drivers were unable to adopt an avoidance manoeuvre. Conversely, other drivers may have had a relatively large amount of time available in which to choose an appropriate response and the fact that the accident still occurred may indicate that the avoidance manoeuvre selected was not appropriate or was not performed at the correct moment. These drivers would be classed as having used an avoidance measure despite obvious deficiencies in the selection and utilisation of such measures. An additional point concerning this discriminant analysis is that the solution only accounted for a relatively small proportion of the overall variance, just under 10%.

Despite the reservations about this analysis, it was felt that it may reveal factors which may predispose some drivers to be better able to choose an appropriate avoidance response than others. It might be expected that experience of general driving and particularly near-accidents would ensure that a driver is better prepared to deal with similar situations in the future. Therefore, it was not surprising that an exposure variable emerged as a good predictor of group membership, in this case annual mileage. Duration of exposure did not emerge as a strong predictor and this may indicate that it is higher exposure obtained in more recent times that is more relevant. Avoidance techniques learnt during the formative years of driving may be removed from a driver's repertoire as a result of under-utilisation whereas recently-rehearsed manoeuvres are more likely to be available for use.

Perhaps the most significant aspect of this analysis was the fact that the best discriminator of drivers who adopted an avoidance strategy and those who did not proved to be whether the driver received training from a qualified driving instructor or not. That the respondents who did receive such training were more likely to report non-adoption of an avoidance technique is extremely interesting as it implies that this method of tuition is less able to provide drivers with an appropriate repertoire of avoidance techniques. Prior to qualification, drivers should be in a position to competently deal with the majority of situations they are likely to encounter on the roads when driving unsupervised. Naturally, this is expanded upon and refined by experience, and the emergence of a variable measuring exposure in this analysis appears to confirm this. Nevertheless, it is clear that it is advantageous for a driver to begin their qualified driving history with as complete a repertoire of appropriate avoidance strategies as possible and the evidence presented here suggests that those trained by a qualified instructor are less likely to have such a repertoire.

This finding confirms the fears expressed by Brown, Groeger and Biehl (1987) (see quotation in Section 1.4.2) that the skills acquired during the standard method of training leave newly-qualified drivers with an all-too-limited range of methods for dealing with the demands imposed by modern driving. It is suggested that this may be due to over-reliance upon skill-based activities rather than more knowledge-based aspects of driving as noted in Section 1.4.2. These issues will be discussed in greater detail in the general context of driver training in a forthcoming section (9.8). Meanwhile, attention will now be focused upon discussion of the analysis performed to discriminate between those drivers who felt that they could have prevented their described accident and those who felt that they were helpless and therefore that the accident was not preventable.

9.5.2 Accident Preventability

It was suggested that if a respondent claimed that there was nothing they could have done to prevent the accident described, they were essentially helpless in that situation. In many accident scenarios, it is argued that all drivers involved will have been able to adapt their behaviour in some way as to minimise the possibility of a collision resulting. Therefore, a driver who claims that there was nothing they could have done to prevent the impact could be thought of as displaying a perceived lack of control over their involvement in that situation. Conversely, those drivers who admitted that they could have done something and who, by definition, did not implement such measures could be thought of as being ill-prepared to deal with the accident situation. It was therefore felt to be of great interest to study how these two groups of drivers differed.

Not surprisingly, the most effective discriminator was found to be the metavariable measuring the drivers' self-rating of the degree of negligence displayed by their driving. That the 'accident-preventable' drivers did not implement their suggested prevention measure does indeed suggest a degree of negligence on their part. On the other hand, this difference may be exaggerated by the 'accident not-preventable' drivers showing a tendency to reinforce a belief of themselves as a competent driver (see also Section 9.3.4) by responding in a manner consistent with that of the hypothetical 'good driver'. In other words, they would have felt that the causal factors implicated in the accident were beyond their control and therefore they could not be thought of as negligent by not adopting a prevention strategy.

The second most effective discriminator was found to be that recording the receipt of advanced training, with the 'accident-preventable' group being more likely to have received advanced training. In contrast with the notion discussed in the previous 1ection concerning pre-test tuition from a qualified instructor, it is hypothesized that those drivers with some form of additional tuition may be equipped with a more fully developed repertoire of avoidance and prevention strategies which they can adapt to the demands of a potential accident situation. In some ways, this supports the finding of Fazakerley, Davies, Henderson and Sheppard (1980) that attendance on an advanced training course considerably improves drivers' knowledge.

If this is so, the implication is that the 'accident not-preventable' group actually could do nothing to prevent the accident due to their lack of prevention strategies. However, the fact that those drivers with additional training did not actually do anything to prevent the accident suggests that they may often be unable to implement strategies from that repertoire, merely more aware of the possibilities. Indeed, it is suggested that this awareness factor may constitute the main difference between the groups rather than any ability-based criterion. Certainly, it might be expected that a driver who is in possession of an increased awareness of the range of possibilities for accident-prevention would be more likely to describe themselves as negligent if a prevention strategy was not employed.

The main question that arises from this analysis must ask why, if these 'accident-preventable' respondents could have done something to prevent the accident, they did not implement this procedure, particularly if they are generally more aware of the possibilities. Unfortunately, this was not asked of respondents, mainly due to lack of space, and it is suggested that this matter be a prime consideration for future research on this issue.

The finding from the chi-square analysis, that admitters of culpability were considerably more likely to state that there was something they could have done to prevent the accident, is consistent with expectation and common sense. If a driver claims responsibility for the accident it follows that they feel that there was something they could have done. Conversely, a respondent who feels that they were the 'victim' of the accident, whether rightly or wrongly, is more likely to reinforce this claim by stating that they were powerless to prevent the accident. Indeed, it is surprising that there was not even greater correspondence between these variables.

9.6: DISCUSSION OF ANALYSES INVOLVING MAIN ACCIDENT TYPES

9.6.1 Rear-End Shunt Accidents

Rear-end shunts were found to be the most frequent single accident form in which the respondent was not the 'victim' of another driver's manoeuvre. However, the proportion of this type of incident for all non-victims was found to be in excess of the figure suggested by Sabey (1973) (29% against 13%). It would appear that the rear-end shunt generally occurs on the approach to a junction, or possibly just prior to the turning point (eg. the 'Give Way' line), and in many cases may occur whilst queuing to leave a junction. Not surprisingly, the avoidance measure suggested by the majority of drivers involved in this form of accident was braking, although many reported swerving and some used both techniques. However, it is clear that the measures were implemented too late to avoid the collision. Of more interest are the prevention measures suggested by these drivers, and it is noteworthy that almost half felt that the other driver (presumably the one immediately in front) could not have done anything to prevent the collision, a clear admission of culpability. In addition, over half believed that they should have been more observant, clearly intended to refer to the vehicle or queue of vehicles immediately in front. Almost a quarter of these respondents reported that the incident could have been prevented had the other driver been more decisive. This must occur when the respondent is the driver of a vehicle second in line to make the manoeuvre either to enter or leave the junction and where the driver in front may show some signs of hesitation. However, it is proposed that the assumption that the driver in front will move at a particular moment is one of the major contributory factors in this type of accident and appears to confirm the suggestion made by Wilde (1980) quoted in Section 5.3.1 concerning the different norm systems that appear to be in operation in this situation.

Although accounting for a small proportion of the variance, the discriminant function analysis was of interest in that, as with the analysis concentrating upon the issue of accident-liability, the sex of the respondent was found to be the most important discriminator. That males were found to be more likely to be involved in this form of incident merely serves to re-emphasise their over-involvement in accidents. However, it is probably of more interest that the measures of driving exposure, whether gauged by duration or intensity, were not able to distinguish rear-end shunt-involved drivers from non-accident-involvees. This implies that greater driving experience has little effect upon involvement in this form of incident.

It was noted above that these accident-involved drivers tended to fault themselves more than other drivers and this was certainly confirmed by the predictive power of both INCPFAC1 and INCPFAC2. The fact that they were more likely to feel that driver variables and less likely to feel that environmental variables will influence their future accident-involvement chances suggests that the circumstances of the described accident were used to make these assessments. This also manifested itself in the predictive ability of the metavariable describing the probability of careless junction approach practices resulting in an accident, which the rear-end shunt-involvees felt were more likely to lead to a collision.

Perhaps the most surprising aspect of this analysis was the failure of the metavariable measuring inattention to vehicles in front and impatience (REPOFAC1) to discriminate between the two groups, as it would appear to make sense that both tendencies would be implicated in this form of incident. One possible explanation is that this may be a reflection of these respondents' either not realising that they are inattentive, and therefore failing to report it accurately, or not being truthful. Of course, there remains the possibility that these drivers are actually no worse at attending to vehicles in front or no more impatient, but evidence from the suggested prevention measures previously discussed implies that this is not the case in most, if not all, instances.

Unfortunately, the DFA was unable to reveal much about the causal factors implicated in the occurrence of rear-end shunt collisions although the analysis of the prevention measures suggested was extremely revealing. The main conclusions discussed in this section will be compared with those derived from the discussion of the observational data concerning rear-end shunts in the final chapter.

9.6.2 Left-Turn Accidents

Almost half of the respondents involved in left-turn accidents did not adopt any form of avoidance measure, possibly due to a lack of available time. Once the driver entering the junction has decided to begin the manoeuvre and the 'point of no return' is passed, there is probably little that they are able to do if that decision was incorrect and a collision appears imminent. However, a third of these respondents attempted to avoid the accident by braking, although it appears probable that they left it too late to avoid the incident. In contrast to those drivers involved in rear-end shunts, the left-turn-involved drivers felt that they were able to prevent the accident more often than another road user. It should be clear that in all but exceptional circumstances, the driver entering the junction will always be responsible for any resultant collision, the onus being upon them to decide when to pull out, and in light of this it is notable that only 30% of respondents felt that the other driver was powerless to prevent the accident. This highlights the tendency for many drivers to attempt to ascribe blame to another party wherever possible and such factors as other drivers travelling too quickly may be inaccurate in many cases.

The analysis designed to discriminate between both left-turn and cross-traffic accident-involvees and non-accident involved drivers was not particularly successful with 15% of the variance accounted for. The respondent's sex again emerged as a strong predictor, probably for the same reason as that discussed in Section 9.6.1. However, the emergence of the metavariable measuring poor attendance to vehicles in front and impatience as a good predictor is of more interest. The procedure involved in pulling out into the traffic flow at a junction requires that the driver must make a judgement about suitable gaps between vehicles passing though the junction. Ebbesen and Haney (1973) found that the longer a driver had to wait to enter a junction, the shorter was the gap they were prepared to accept. Although this was contradicted by the findings of the first phase of this research, it has previously been noted (Section 5.3.2) that the measure of gap acceptance used was not particularly satisfactory.

The Ebbesen and Haney finding can certainly be thought of a demonstration of impatient behaviour and this may account for the predictive ability of the metavariable REPOFAC1. However, the metavariable also purports to measure attendance to vehicles in front whilst approaching a junction and this confusion highlights the problem with this metavariable. It is not clear why attendance to vehicles in front should have any correspondence with involvement in left-turn/cross-traffic accidents unless it is simply equivalent to a general inattention measure. Until these two components of driving at junctions are treated as separate phenomena, it is unlikely that this issue can be resolved. The issue is further confused by the fact that the best discriminator in this analysis was the metavariable recording perceptions of the probability of careless junction approach behaviours resulting in an accident. Once again, it is difficult to understand why this should have emerged as a good indicator of left-turn/cross-traffic accident-involvement unless it is a measure of general carelessness at junctions. One of the possible key factors in this type of incident is the judgemental criteria adopted by drivers when pulling out onto a junction. Due to the nature of this second phase of the research, this aspect of driving was not considered and it is suggested that future studies should certainly include some form of judgemental assessment. This issue will be given further consideration in the final chapter (Section 10.2.3).

It should be noted that the reliability of the discriminant function analysis should be questioned as the left-turn incidents were combined with the cross-traffic incidents and, due to the presence of missing values on some of the predictor variables, it is likely that the data for under 20 actual left-turn respondents were included in the DFA. The implications of this combination of accident-types will be dealt with in the next section.

9.6.3 Cross-Traffic Accidents

More examples of cross-traffic accidents were reported by the respondents than left-turn accidents, but the pattern of avoidance techniques for the two forms is reasonably similar. Just under half of these respondents also reported not adopting any avoidance measure, again possibly due to a lack of available time in the circumstances. However, a considerably larger proportion felt that they were powerless to prevent the accident in contrast to roughly half who felt that this was true of another road user. This type of incident has similarities with left-turns in that it also requires a judgement to be made about choosing a suitable opportunity to turn from the main road into the side road. Indeed, the most popular choice of self-prevention measure was to have waited before moving, whilst they felt that another road user should have driven more slowly in over a third of cases.

The implications of the discriminant analysis will not be discussed in relation to cross-traffic incidents as their combination with left-turn accidents means that the implications for these left-turn accidents, discussed in the previous section, are also relevant for cross-traffic accidents.

The evidence from the avoidance and prevention measures suggested by the respondents involved in these two forms of accident implies that there may be sufficient correspondence between left-turn and cross-traffic incidents to justify combining them for the purposes of the discriminant analysis. Both types of manoeuvre are reliant upon the driver making an accurate assessment of the suitability of a gap in the traffic as well as upon their ability to execute the manoeuvre and join the traffic flow as without disrupting that flow. However, it is recommended that this analysis should be treated with a certain degree of caution, and the evidence for combination of the two categories as purely circumstantial. Indeed, it is proposed that each type of incident should be treated as a unique accident form. The potential number of elements contributing to each type of incident implies that there will be many sub-categories of incident within any general grouping. It is concluded that, before any firm conclusions about these accident types can be made, each must be subjected to individual scrutiny, using a large number of examples of each accident type to ensure a reliable and valid analysis.

9.7: DISCUSSION OF FACTORS CONTRIBUTING TO SCORES ON THE SELF-CENTRED & ILL-MANNERED METAVARIABLE

The metavariable DESCFAC1 measured the extent to which respondents believed their driving to be self-centred and ill-mannered. It was found to be an excellent predictor of accident liability, admission of accident culpability and was also found to have the ability to discriminate between those drivers trained mainly by a qualified instructor and those trained by a friend/relative or a mixture of the two types of training. It has already been noted (see Section 9.4.1) that a metavariable with the same label, constructed from a very similar set of bi-polar descriptor variables, was found by Guppy, Wilson and Perry (1990) to be significantly correlated with accident rates when experience was controlled. Quite clearly, this metavariable is measuring an important aspect of driving and accident-involvement and it was felt that it would be useful to examine those factors which are related to this construct.

The number of accidents a respondent reported being involved in was a strong predictor of scores on DESCFAC1, confirming the association discussed in Section 9.4.1. Likewise, male drivers were found to be more self-centred/ill-mannered and this ties in with the over-representation of male drivers in the accident statistics (eg. Foldvary, 1979). The fact that the more self-centred/ill-mannered drivers were found to be more likely to rate their future accident-involvement possibilities as being greater than those of the average driver suggests that they have a fairly realistic perception of the apparent dangers inherent in their driving style. Perhaps more revealing is the predictive ability of the variable recording whether the respondent is a qualified public service vehicle driver or not. The PSV drivers were found to have generally lower DESCFAC1 scores and it is hypothesized that this may be connected with the issue of responsibility. By definition, these PSV drivers are responsible for the personal safety of large numbers of people at any one time and it is obviously preferable if these drivers adopt a less aggressive style of driving. This issue of responsibility could be investigated by looking at the differences on DESCFAC1 between younger male drivers who have children and those who do not when factors such as exposure, accident history and age are controlled for.

The variable that was found to have the largest influence on scores on this metavariable was the respondent's age, with younger drivers giving more self-centred/ill-mannered self-descriptions. This suggests that adoption of this driving style is largely a question of individual maturity, particularly for male drivers. This is consistent with the view proposed by Jessor (1984) who suggested that the over-representation of younger drivers in accident statistics was just one of many manifestations of a general 'health risk behavioural syndrome'. In other words, young drivers behave as they do because they are young. It might be argued that an alternative explanation of the tendency for younger drivers to describe themselves as more self-centred and ill-mannered could be their relative lack of driving experience. However, if that were so, the duration or intensity of exposure variables might have been expected to emerge as good predictors. As neither did, the evidence presented here suggests that it is age, rather than experience, that forms the main determinant of DESCFAC1 scores.

It should be noted that it may not necessarily be actual driving patterns that change as drivers age. Younger drivers may respond to the constituent items in such a manner as to project a desired self-image that they believe is expected of them by their peer group. As they age, this desire to conform with peer group expectations may diminish and they may begin to respond in a more honest manner. This is purely hypothetical and further research would have to be conducted to either support or contradict this notion. Bliersbach and Dellen (1980) felt that the type of driving described by this metavariable developed in the early stages of learning to drive and, as it is implied in the current research that this type of behaviour is a major factor connected with accident-involvement, this has clear implications for driver training. This will be considered in the final chapter (Section 10.4).

Two closely related phenomena to self-centredness and ill-mannered behaviour are those of aggression and assertiveness. It may be remembered from Section 6.1.2 that Whitlock (1971) believed that up to 85% of road accidents result from aggressive behaviours. Additionally, note was made of the study by Parry (1968), in which drivers who achieved higher aggression scores were found to be more likely to become involved in road accidents. It certainly makes intuitive sense that drivers who behave aggressively will be placing themselves at greater risk of accident-involvement than those who are more defensive.

However, it is interesting to note that this metavariable was not found to explain the differences between culpable drivers and accident 'victims'. The implication is that aggressive behaviour does not actually *cause* accidents, merely predisposes a driver to be more likely to be involved, whether as the guilty or the innocent party. Indeed, comparing the mean DESCFAC1 scores for culpable drivers and 'victims' (see Appendix DD) with those for all drivers (see Appendix Z), it can be seen that both groups of drivers have higher than average scores and therefore have more self-centred and ill-mannered self-descriptions. The implication that accident 'victims' may also have a tendency to display more aggressive behaviour patterns is probably contrary to expectation and has clear repercussions for remedial measures. These will be discussed in the final chapter.

9.8: DISCUSSION OF ANALYSES CONCERNING TRAINING ISSUES

9.8.1 Novice Driver Training

One feature of the analyses concerning the type of tuition received by respondents was that which offered initial confirmatory evidence to support the finding reported by Skelly (1968) (see Section 1.4.2). Skelly discovered that those drivers who received their tuition from a friend or relative had the most successful miles-per-accident record, and the same thing was found to be true in this instance. On the other hand, whereas Skelly found that those in receipt of tuition from a mixture of professional and private sources produced the worst record, the records of these and professionally taught drivers were found to be virtually identical in the current study.

It should be noted that there were some differences between the way in which the data was gathered in the two studies that may help to explain the slightly different results. Firstly, Skelly required that drivers must have received all of their tuition from a driving school or friend/relative to gain inclusion into the relevant group, any combination was counted as tuition from a mixture of sources. This may be the ideal situation, but it was argued that it does not reflect the real situation that closely, with the overwhelming majority of drivers receiving some mix of training styles. In a survey of the type carried out, it would have been unlikely that many respondents could have claimed to have been taught exclusively by a qualified instructor or, especially, by a friend or relative. To allow for this, the emphasis of the question was altered to enable respondents to indicate which source had provided them with *most* of their pre-test training.

The second difference between the studies probably had more influence on the outcome. Skelly looked at the miles-per-accident records of newly-qualified drivers in the first year after qualification. This does not take into account an effect later discovered by Pelz and Schuman (1971), who found that accident-involvement rates reached their peak after around two to three years after qualification. In this study, all respondents were considered, and the accident and mileage figures used were those reported for their complete driving history.

It is recognised that the measure of driving experience used in this study is not ideal. This was defined as the product of the current annual mileage and the number of years of regular driving that were reported. Therefore, the final experience figure is based upon the assumption that all drivers had the same annual mileage over their entire driving history. Any such assumption is clearly unfounded, and in most cases probably quite misleading. However, this was accounted for in the subsequent analysis of covariance which showed that the major sources of variance in the different accident counts were due to experience and exposure effects, rather than to the types of training received.

Additionally, it is unclear why the mean driving experience of those drivers in receipt of tuition mainly from a friend or relative should be almost twice that of those in receipt of the other sources of tuition. It may be that drivers who choose to be trained by a friend or relative are generally more interested in driving per se, and may even feel that driving schools are not the best source of training. However, it is probably more likely to be a consequence of the fact that receipt of tuition from a professional source is a relatively recent phenomenon. Older, and therefore generally more experienced, drivers are less likely to have had the opportunity to train with a professional school and many will have had to rely upon friends or relatives to teach them to drive.

This difference is likely to have had a considerable effect on the miles-to-accident ratios, even though these friend/relative-trained drivers also recorded the highest mean number of accidents. To overcome this problem of experience it would have been necessary to ask a lengthy series of detailed and repetitive questions, and it was felt that this would not have been practical under the circumstances, and given that this was not intended to be one of the central analyses. However, it is felt that the analysis of covariance was able to provide sufficient evidence to suggest that the accident counts of drivers in receipt of each form of novice driver training do not significantly differ, in direct contrast to the findings of Skelly (1968).

It was therefore quite revealing to find that the discriminant function analysis was able to demonstrate some differences between the groups. Those respondents who were trained by a friend or relative were found to differ from those who had professional or mixed tuition in terms of their advanced driving experience, accounting for much of the variance between the groups, and lower probability that they owned their most-driven vehicle. It has previously been noted that the differences due to driving experience are likely to be a result of the increased availability of professional tuition to less experienced, and therefore mostly younger, drivers. Although the reason why friend/relative-trained drivers were found to be less likely to drive their own vehicle remains obscure, it is felt that other differences are worth noting.

Those respondents who received the majority of their tuition from a friend or relative were found to describe themselves as less negligent than those trained by a professional instructor or by a mixture of the two types. Although this does not necessarily mean these drivers actually are less negligent, the implication is that these drivers are more aware of their driving environment and possibly also more safety-conscious. It is clear that both factors would be assets in a driving style geared towards accident-avoidance.

The second function of the discriminant analysis was possibly more interesting as it highlighted differences between those drivers taught by a qualified instructor and those by either a friend/ relative or a mixture of the two. Once again, driving experience was found to be a strong predictor of group membership on this function with the qualified instructor-trained found to have less experience, probably for the reason previously discussed. However, it was revealing to discover that these drivers were found to have the most optimistic view of their future accident-involvement chances. In theory, respondents should have stated that their chances were equivalent to those of the average driver. Although the general trend was for respondents to underestimate the probability of their accident potential in relation to the average driver, this trend was most pronounced in the drivers qualified by a professional instructor. This implies that these drivers are equipped with a more unrealistic view of their personal accident potential and although it cannot be ascertained whether this arrogance is a product of the method of training received, the evidence suggests that this may be so.

In addition, it was notable that the qualified instructor-trained drivers were found to be more likely to describe themselves as more self-centred and ill-mannered. This metavariable has been linked with accident-liability in previous sections (see Section 9.4.1) and this suggests that drivers trained by qualified instructors have a tendency to report driving in a manner also found to be implicated in accident-involvement. Therefore, although these drivers do not appear to be more accident-involved than those trained by other methods, the implication is that many are driving in a manner that will predispose them to be more likely to become accident-involved in the future.

The self-descriptor metavariable recording the driver's perceived level of timidity was found to indicate that professionally-trained drivers were likely to describe themselves as more timid. This suggests that these drivers may have less confidence in dealing with the demands of everyday traffic and it is probably notable that this factor was also found to be linked with accident-causation. The reasons why more timid drivers may be more likely to cause accidents was discussed in Section 9.4.3, but it is of some concern that professionally-taught drivers describe their driving styles in a similar manner to those found to be culpable for accidents. Individual driving style is presumably somewhat influenced by the mode of training undertaken and the results of this analysis appear to suggest that there are aspects of this form of tuition which may predispose some drivers to partake in behaviours that are likely to cause accidents. Of course, there is no direct evidence to support this supposition and further research would be necessary to establish such a link between methods of driver training and accident-culpability should it exist.

It should be noted that one problem with the method of collecting data on the form of novice training received was that it did not account for the total amount of tuition received. For example, a driver who received the majority of their training from a friend or relative may still have taken as many lessons from a qualified instructor as learners who only used this form of tuition. Some of the former category of trainees may have boosted this average level of professional tuition with a large number of private lessons and therefore been in receipt of considerably more tuition in total. If the quantity of the latter form of tuition considerably outweighed the amount of former, the questionnaire would have forced such a respondent to state that they received most of their tuition from a friend or relative, despite the accompanying high level of professional tuition.

Nevertheless, the evidence presented here, albeit circumstantial, appears to confirm Brown, Groeger and Biehl's (1987) assertion (see Sections 1.4.2 and 9.5.1) that modern training methods leave driver ill-equipped to deal with the demands imposed by driving. Indeed, it seems that the methods of tuition offered by driving schools may have some some serious deficiencies in their ability to prepare drivers for the 'real world', and the implications of these findings will be discussed in the next chapter.

9.8.2 Advanced Training

When the effect of additional, post-test professional training upon the mileage-per-accident ratios was investigated, an interesting tendency was noted. Although the mean ratio for those drivers in receipt of mixed pre-test training was virtually identical regardless of whether any additional training was taken, the mean ratio for those trained by a qualified instructor improved dramatically, whilst that for those trained by a friend or relative showed a marked reduction. This implies that advanced training has a positive effect upon the former drivers, whilst being detrimental to those falling in to the latter category.

The first finding should not be surprising, given that the advanced courses are presumably designed to counteract the deficiencies that drivers tend to display. However, it is more surprising that advanced training should effectively increase the chances of those drivers initially trained by a friend or relative becoming involved in an accident. It is possible that, although their accident records are relatively exceptional, these drivers may, in some respects, drive in ways felt by advanced instructors to be contrary to the desired norms. These drivers may then be faced with a major change in driving style, which they may only partly be able to adopt, and the mixture of tuition forms may create a counter-productive clash of styles.

One of the problems with such retrospective studies is that the candidates for advanced courses were self-selected. In other words, drivers participating in advanced driving courses did so voluntarily, and it is possible, indeed likely, that they differ from those not interested in taking part in some crucial ways. For instance, the sub-set of drivers who were initially taught by a qualified instructor, and who subsequently received advanced tuition, may have had a 'safer' miles-to-accident ratio than that of the whole population prior to participation in the advanced course, the effect being obscured by the large ratio of other drivers to those in this sub-group. It is unfortunate that, until a longitudinal study is carried out to investigate this possible effect, or indeed until advanced training becomes compulsory, this must remain conjecture.

Although participation in some form of advanced training course appeared to have a positive effect on miles-to-accident ratios, no significant differences were found between the accident counts for those who did and did not receive advanced training when exposure was controlled for. This suggests that advanced driving courses have no effect upon subsequent accident counts. It is worth noting that, regardless of the form of novice driver tuition received, those taking advanced training had consistently higher mean number of accidents than those in the corresponding pre-test groups with no advanced training. The analysis of covariance suggested that this is more likely to be a result of increased exposure and/or experience than anything else.

Despite this, the discriminant analysis performed to investigate the differences between drivers in receipt, and those not in receipt, of advanced training was highly satisfactory and very revealing. Those respondents who claimed to have participated in some form of post-test training were found to report being better attenders of vehicles in front and more patient and were also more likely to attend to 'vulnerable' road users at junctions. The first-named pair of factors was found to be a strong predictor of accident culpability and admissions of culpability, these qualities being less likely to be found in the culpable drivers than the 'victims' and were also less likely to be culpability 'admitters' than 'deniers'. These findings imply that advanced training tends to improve the general attentiveness and awareness of drivers and the lack of impatience and increased attendance to vulnerable road users suggests a more considerate driver. Certainly, a self-centred/ill-mannered nature was found to be more prevalent in junction-accident-involved drivers and it is likely that a higher degree of consideration to other road users will be highly beneficial in terms of accident-avoidance.

It should not be surprising to discover that driving as part of work emerged as a good predictor of drivers who have received advanced training. From Table 8.31 it can be seen that several of the forms of advanced training taken were work-related and this predictive ability is likely to be a result of the fact that many jobs in which driving plays a large role (eg. bus driver), additional training is a necessary requirement. The other major factor that emerged from this analysis was the fact that the advanced-trained drivers were less likely to view careless junction negotiation practices as being likely to result in an accident. It was previously implied that the receipt of some form of additional training tended to ensure that drivers were more aware of their environment, particularly the presence of other road users, and the consequences of particular behaviour patterns. The fact that they report feeling that careless junction negotiation practices as being less likely to result in an accident appears to contradict this assumption. If the advanced training is effective, it might be expected that these drivers are better junction negotiators than average and the view expounded may be a reflection of their own junction-negotiation capabilities rather than those of all drivers. Of course, this is purely speculation and it would require further research to determine whether this is so.

It has been found that the receipt of advanced training does not seem to affect accident-involvement probabilities. Once again, self-selection for advanced training courses, as discussed above, may be partially responsible for this. Nevertheless, these drivers were found to report characteristics associated with careful and considerate driving. Indeed, the fact that these drivers reported some characteristics in direct opposition to those reported by accident-culpable driver suggests that differential accident rates may be uncovered if the quantity of accidents the driver were culpable for was used as the dependent variable rather than accident liability. Unfortunately, this information was not collected in a reliable format in the current study (merely relying on the respondents' subjective assessments) and greater detail of all accidents the respondents had been involved in would have to be recorded before this analysis could be performed.

9.9: SUMMARY OF CHAPTER 9

This chapter discussed the results of the analyses performed on the data from the questionnaire survey. Firstly, the overall methodology adopted for the study was discussed. The relatively low proportion of questionnaire returns was felt to be party due to the length of the questionnaire and the contentious nature of the accident items. The received sample was found to be representative of the population, although it was felt that the slight over-representation of younger female drivers was more likely to be a result of response bias than inadequate sampling. It was felt that, while the metavariables used for the analyses proved to be useful, they were far from comprehensive, and it was suggested that more extensive piloting of items should be employed for any similar future research. The accident information provided by some of the respondents was found to be too vague, and suggestions for increasing the quality of recording this type of information were made. The possibilities for some further analyses were mentioned, and it was felt that particular emphasis could be placed upon issues concerning vulnerable road users.

The sample obtained form the police accident records was found to differ from the other two samples on a number of items, particularly reporting a significantly higher annual mileage, and these differences were felt to be a consequence of their higher level of accident-involvement. The accident items showed a tendency for drivers to attribute blame for the accidents onto other drivers in accordance with the literature. Although some reservations about the quality of some of the accident descriptions were expressed, it was concluded that the majority were probably sufficient to allow accurate culpability assessments to be made.

The principal components analyses performed on most sections of the questionnaire produced generally very useful metavariables, although concern over the nature of the reported behaviour items was expressed.

The issues of accident liability and accident culpability were discussed. The comparison between these analyses was of special interest as it was discovered that the majority of predictors of liability were descriptive in nature whilst the predictors of culpability were mainly found to be attitudinal items. It was felt that the emergence of sex and exposure variables as good predictors of accident liability conformed to expectation, although the high predictive ability of one of the self-descriptor metavariables was considered to be of most interest. The issue of junction accident culpability was particularly of note as very few of the predictors of accident liability were also found to predict culpability and it was suggested that all accident-involved drivers, regardless of culpability, may often display a tendency to drive in ways which place at increased risk of accident-involvement. The evidence suggested that the differences between culpable drivers and the 'victims' were at least partly a result of differences in perceptions of danger in certain situations and in their reported driving behaviour patterns.

Drivers who denied culpability tended to describe themselves in what was argued to be a more socially-acceptable manner, and concern over the reliability of these drivers' responses in general was expressed. In general, these culpability deniers were found to respond to items in such a way as to correspond with this denial and therefore maintain their self-image of being a capable driver. The adoption of accident avoidance measures was discussed, although minor reservations about the analysis were expressed. It was speculated that the reason why drivers trained by a qualified instructor were found to be less likely to adopt some avoidance measure may be a consequence of an inability of that form of tuition to prepare drivers adequately for the demands of the 'real-world'. It was also felt that drivers who believed that there had been nothing they could have done to prevent their accident may have been responding in a way that retained a level of self-consistency, although they were found to report a higher degree of negligence. The suggestion that advanced training may be useful in presenting drivers with a increased range of possible prevention and avoidance behaviours emerged from the discussion of this analysis.

Those drivers involved in rear-end shunts tended to be more willing to attribute blame to themselves, whilst those involved in both left-turn and cross-traffic accidents were more likely to find factors other than their own driving to explain their accidents. Some potential problems with the nature of the discriminant analyses performed were discussed, and in particular, it was felt that there was insufficient justification for combining the latter two forms of accident.

Factors associated with the major self-descriptor metavariable, identifying self-centred and ill-mannered drivers, were discussed and the contribution of the concept of social responsibility to this metavariable was speculated upon.

The discussion of the discriminant analysis concerned with novice driver training included the assertion that drivers trained by a friend or relative displayed produced responses that indicated a greater awareness of their driving environment than their qualified-instructor-trained peers. These latter drivers were also found to report some characteristics also reported by accident-liable drivers and the implications of this were discussed. Finally, it was noted that those drivers who received advanced training were found to display more traits associated with a 'good' driver, such as increased attentiveness, consideration towards others, and increased care.

CHAPTER 10:

GENERAL DISCUSSION

10.0: OVERVIEW

Whilst the previous chapter discussed the main findings from the questionnaire study, the main purpose of this final chapter is to compare these findings with those obtained in the observation study and discuss their implications for the literature. The first section (10.1) deals with the effectiveness of the overall methodology used to investigate the main areas of concern outlined at the end of Chapter 1. Three main forms of accidents at junctions have been covered by this research and Section 10.2 brings together the observed and reported information concerning these accident forms. In addition, this section also discusses the implications for accidents at junctions in general and also notes accident forms not covered by the study.

Section 10.3 discusses the main findings of the research in relation to three main areas introduced in Chapter 1: the analysis of driver errors; risk models; and the study of driving schemata. Chapter 1 also highlighted training as probably the most effective method of bringing about behavioural change and so the final main section (10.4) of this chapter considers the implications of the findings for driver training programmes. Recommendations for further research are presented in Section 10.5, and the final section (10.6) summarises the main conclusions of the study.

10.1: REVIEW OF THE OVERALL METHODOLOGY ADOPTED IN THIS STUDY

It may be remembered from Section 5.4 that it was felt that the methodology adopted for the observation study was mostly able to satisfy the research objectives by providing a reasonably comprehensive guide to driving behaviour at four different forms of junction. The only major concern that was expressed was over the ability of the obtained sample to provide a truly representative picture of the population of drivers who use the four junctions in question. Similarly, it was argued (see Section 9.1) that the methodology adopted for the questionnaire study satisfied the criteria set by providing much useful information about factors associated with accident-involvement at junctions. The main problem expressed with the questionnaire method concerned the lack of comprehensive details about the accidents themselves and, more generally, the fact that the full range of behaviours and opinions were not covered by the instrument.

It was also previously noted (Section 2.3.1) that some researchers (eg. Michon, 1980) have expressed doubt over the questionnaire technique's ability to describe accurately driver behaviour. Although the current research is unable to either directly support or dismiss such concerns, much of the evidence is encouraging. For example, the variables measuring sex, experience and exposure were found to be the most successful predictors of accident-involvement, confirming the long-established notion that these factors are heavily implicated in accident-involvement (eg. Brown, 1982). In addition, other findings confirmed more common-sense notions - drivers involved in more accidents describing themselves as being more self-centred and ill-mannered than other drivers, for instance. Of course, such matters do not constitute proof that the findings of this questionnaire survey are an accurate reflection of the 'real world', and it is clear that much further research needs to be conducted.

The main advantage with observing driving behaviour at junctions is that it was able to quantify certain behaviours, such as the incidence of correct signalling behaviour, and thereby establish the extent of particular 'problems'. On the whole, the inferential analyses in the first phase of the research were able to provide little more than 'obvious' answers to certain questions. For example, the finding that shorter following distances are more likely to result in a rear-end traffic conflict. However, it is argued that the technique of using a combination of such 'objective' and more 'subjective' research techniques, as suggested by Knapper and Cropley (1980), was able to provide much valuable information concerning the possible directions for future research in the study of accidents at junctions by, firstly, quantifying certain behaviours, and secondly, by identifying factors associated with these behaviours.

It is certainly unlikely that subjective and objective assessments of driving behaviour at junctions could have been obtained from such a large sample by using alternative techniques. However, it has been noted that other information could have been used to supplement the data obtained. For example, in Section 9.1.1 it was noted that more may be learned about left-turn and cross-traffic accidents by studying the performance of drivers known to have been involved in such incidents on some judgemental tasks.

In addition, a major concern with the type of research design adopted in the second half of this study is that it is necessarily retrospective, and it is therefore difficult to make inferences about causal relationships, a view supported by van der Colk (1988). In these circumstances, it could never be determined whether a certain opinion (for example) found to be associated with accident-involvement actually contributed to the occurrence of the accident, or whether the accident gave rise to the formation of that opinion. The analysis described in Section 8.5.1 showed that drivers deemed to be 'victims' of the described accident were more likely to feel that careless junction approach styles would result in an accident than did the culpable group of drivers. The problem here, expressed in Section 9.4.3, is that it is not possible to determine whether this belief was formed as a direct result of accident experience or whether these drivers tended to believe that this was true prior to the accident.

The only way to overcome such problems is to adopt a longitudinal research design in which the 'progress' of a large sample of drivers is followed over a number of years. By adopting this method, those factors (ie. opinions, beliefs, perceptions etc.) which are modifiable by experience, particularly accident experience, and those which are relatively stable over time can be distinguished. However, by necessity, this would involve considerable commitment financially and temporally, and, for the purposes of the current project at least, highly impractical.

10.2: OVERALL DISCUSSION OF ACCIDENT FORMS

10.2.1 General Accidents

One of the major problems in attempting to determine factors implicated in accident-involvement and causation is that each accident has a unique set of circumstances leading up to its incidence. Nevertheless, the purpose of research of this nature is to attempt to determine factors which predispose some drivers to be more likely to become involved in accidents than others. Although many of the factors found to predict accident-involvement, such as age and exposure, conformed to expectation, others were more revealing. Particularly noteworthy was the generally high predictive power of the principal self-descriptor metavariable (self-centred/ill-mannered).

An additional analysis to determine variables associated with accident-causation produced a different set of predictors suggesting that the factors linked with accident-involvement and accident-causation are not common. The majority of predictors associated with accident culpability were attitudinal or reported behaviours and the fact that these were not found to be related to accident-liability implies that a driver who is in possession of such attitudes will not have an increased (or decreased) chance of accident-involvement. However, it may be remembered from Section 9.4.3 that it could not be determined whether such attitudes contribute to the causation of accidents or whether they developed as a consequence of the accident.

Conversely, the results imply that culpable drivers and 'victims' should be equally accident-liable as they were not found to differ in terms of the main liability-predicting variables such as duration of exposure or scores on the self-centred/ill-mannered self-descriptor. This highlights the difficulty of assigning culpability to a single driver in an accident and it appears that it may be more appropriate to view both (or all) drivers as being at least partly responsible for the occurrence of the accident. This appears to confirm the view expounded by Wilde (1980) who tells of a driver who had been involved in a number of accidents within a short space of time who was not deemed to be responsible for any of them. Wilde asserts that, although the behaviour of this driver was within the formal rule system, her:

"...deviancy from general social practice made her behaviour unpredictable to others." (Wilde, 1980, p. 440).

In other words, whilst not being responsible for carrying out the final manoeuvres from which the collisions resulted, it seems that this driver was behaving in a highly unpredictable manner which essentially brought about the occurrence of those accidents. Likewise, from the current study, many of the 'victims' may be equally responsible for their accidents by driving in a certain manner such as that described by the self-centred/ill-mannered metavariable. Maintaining this example, it follows that adoption of an alternative, less aggressive driving style by these 'victims' might have prevented the accident and that both parties in this situation should be considered to be truly culpable. In light of this, it is suggested that the term 'victim' may be somewhat misleading in this context.

This also implies that the differences found to exist between the 'culpable' drivers and the so-called 'victims' may be a function of involvement in the accident rather than the converse. As previously noted, the only way to resolve this problem would be to conduct a longitudinal research project, following the progress of a large sample of drivers and noting how attitudes, perceptions and reported behaviours change over time and how these are linked to accident-involvement.

However, there remains the possibility that these differences between the culpable drivers and 'victims' may be genuine accident-causing traits. Whilst it may be impossible to prevent drivers from actually possessing such characteristics, which may be a reflection of traits that are generalisable to many activities, it may be possible to enable target groups to be identified for remedial training programmes. It is theorized that training programmes could aim to identify drivers who are likely to develop such tendencies, and then concentrate upon ways to prevent the development of these characteristics.

The metavariables derived from items in Section 3 of the questionnaire, concerning the perceived probabilities of a number behaviours resulting in an accident, proved to be very useful distinguishers of certain sub-groups of drivers. For instance, it was found that accident-culpable drivers were less likely to feel that careless and egocentric junction approach techniques would result in an accident than the 'victims'. Assuming that this is a stable characteristic, unchanged by accident experience, it appears that these drivers may have a somewhat distorted view of the objective risk of poor junction approach styles. In Näätänen and Summala's (1976) terms (see Section 1.6.4.1), this implies that these drivers' subjective risk threshold is set 'too high', and that their 'fear monitors' will not be activated at the appropriate time.

Similarly, the idea of schemata suggests that these culpable drivers' schema of, in this case, junction approach styles may be inaccurate. Of course, by definition, schema are modifiable by experience, and the implication is that, if these drivers do indeed have inappropriate schema, it was their own direct driving experience that shaped the form of these schema. From a training perspective, it is surely impossible to ensure that drivers are never exposed to poor driving practices, and therefore it is essential that these practices are interpreted by the driver in question in a truly appropriate manner. To revert back to Näätänen and Summala once again, all drivers, particularly learners, should be provided with accurate information concerning the objective risks of inappropriate behaviours, therefore theoretically ensuring that their subjective risk assessments of all driving situations more closely match the objective risks.

10.2.2 Rear-End Shunt Accidents

Following times and the presence of a queue at the 'Give Way' line were found (see the discussion in Section 5.3.2) to be good predictors of involvement in rear-end shunt traffic conflicts and this was felt to conform with an intuitive assessment of these incidents. It was therefore hypothesized that the study of drivers' reasons for adopting small following distances, and associated perceptions of junction approach behaviours, would be of more use. However, it should be stressed at this point that any comparisons of the two studies reported here imply that it is assumed that the accidents are being equated with traffic conflicts. It was previously noted (in Section 2.2.1) that Cooper (1973) expressed serious doubts about the correspondence between accidents and conflicts, and therefore this assumption may be unfounded. Nevertheless, it is argued that the differences observed by Cooper were in the evasive actions adopted by drivers. In other words, the drivers' reactions to the two events were found to be different and there is no evidence to suggest that the basic manoeuvres and antecedent factors of both accidents and conflicts differ in any significant manner.

Although disappointing in terms of the amount of variance accounted for, the discriminant analysis performed to discriminate the rear-end accident-involved drivers from others showed that the former were generally less likely to feel that environmental factors would increase their chances of accident-involvement and also that driver factors would be less likely to influence such accident-involvement. It was noted in Section 9.5.1 that it is probably more likely that respondents' perceptions of the role of environmental factors in future accident-involvement was a result of direct experience of accident-involvement rather than actually contributing to the described accident. If so, it is possible that such beliefs will be related to the time-lapse since the accident(s) and it is suggested that these effects may be relatively short-lived.

In Reason's (1984) terms, a rear-end shunt can be thought of a 'lapse', since the habitual activity (ie. approaching a junction) is disrupted, and a key element in that activity is omitted or delayed (ie. braking). It may be recalled from Section 1.5.2 that, in their Tripod model, Reason et. al. (1988) posit the notion of General Failure Types (GFTs) - the latent failures 'waiting' for the right circumstances. Adoption of an excessively small close-following criterion, as noted in the observation study, could be thought of as such a GFT and surprise was expressed in Section 9.5.1 that the reported behaviour metavariable supposedly measuring this aspect of driving did not emerge as a good predictor.

The close-following criteria that drivers adopt when approaching a junction must form part of their 'schema' of junction approach behaviour in general, and the main concern should be over how these schema develop. Clearly, each driver will have a representation of a 'safe' and an 'unsafe' following distance, and these will be determined, at least partly, by the prevailing conditions such as vehicles' speeds and the state of the road surface. Therefore that it would clearly be preferable to attempt to instill appropriate following criteria from the very outset of a driver's experience, ie. when first learning to drive.

10.2.3 Left-Turn Accidents

The observation study revealed that the presence of vehicles in a queue or to the side at the 'Give Way' line, along with the initial measure of approach speed, were good predictors of involvement in this form of conflict. The discussion of these incidents concentrated upon the matter of gap acceptance times, which this study could only measure in a relatively crude form. It was concluded that study of the differences in gap time acceptability would reveal more about the circumstances leading to mistakes when entering junctions.

A notable aspect of the questionnaire analysis of the corresponding collisions was the relatively high proportion of respondents who felt that they were less personally responsible for this type of accident than they felt another party to be. Indeed, this was confirmed by the increased belief by left-turn accident-involved drivers that environmental factors would influence their future accident involvement. This is possibly a manifestation of the 'self-serving' attributional bias discussed in Section 6.3.1, in which people display a tendency to attribute successful outcomes to their own performance, yet blame failures on external factors. It seems unlikely that these respondents are responding to a desire to present a favourable self-image, as proposed by Weary and Atkin (1981), as the information was only being presented to the researcher on an anonymous basis. Perhaps more likely is these respondents' wish to retain a more general positive self-image, which presumably affects their responses to any questions concerning the accidents.

However, this may also be a reflection of the issue discussed in the previous section. It was felt that it may be too simplistic to view accidents as having a single causal root (ie. the actions of one of the drivers). Indeed, it is more likely that the behaviours of more than one driver may be responsible for many accidents and this seems particularly appropriate in this form of accident. Many junctions have somewhat restricted sight distances and a driver pulling out to enter such a junction may do so when no other vehicles are in sight. If a vehicle travelling along the main road is doing so at an excessive speed, as born out by many of the descriptions for this form of accident, it is suggested that any resulting collision will be at least as much due to the driving of the latter driver as the former. It is recognised that some respondents may have provided this type of response as a cover for their own misjudgement, but it should be added that in many cases, this may be a genuine phenomenon.

Indeed, it is interesting to note that proportionally many more respondents involved in left-turn accidents than in rear-end shunt accidents felt they were not to blame for the described accident. The self-serving bias should also be in operation for these rear-end accident-involved drivers, and the fact that it appears to be less marked for these latter drivers suggests that, due to the nature of the accident types, other drivers involved in left-turn accidents have more of an active role on the accident causation than in rear-end accidents. This makes intuitive sense if many of the 'other' vehicles involved in the latter class of accidents were at, or almost at, a standstill at the moment of collision, as may well be the case.

Proportionally fewer left-turn accident-involved drivers reported using an accident avoidance measure than did rear-end accident-involved drivers. The finding that those primarily trained by a professional driving instructor would be less likely to implement an avoidance measure suggests that drivers taught by this method may be more likely to be involved in this form of accident. Further testing would be required to ascertain whether this is so, but the implications for driver training (discussed in Section 10.4) should be evident.

Unlike rear-end shunts, Reason's error classification system suggests that left-turn, and indeed cross-traffic, accidents are 'mistakes', as both involve failing to perceive the situation in an appropriate manner, ie. whether or not an on-coming vehicle will be hit if the manoeuvre is carried out. However, Rumar (1990) argues that such incidents may also result from a failure to carry out the appropriate detection procedure in the first place, ie. whereby the driver does not check to see whether any other vehicles are coming or simply does not see them. In Reason's system, this would be classed as either a lapse (if checking procedure is omitted) or a slip (if an additional element distracts the driver). In terms of general failure types, it is proposed that poor judgemental ability would naturally predispose drivers to this form of accident, should additional circumstances arise. Again, the schemata concerned with pulling out across the traffic flow must contain information about acceptable and unacceptable gap times, and whilst the current study was unable to provide much information concerning this matter, it is suggested that future research should aim to investigate this.

It is speculated that drivers that are more at risk of this kind of collision may have 'average' gap acceptance criteria, but under some circumstances chose to adopt alternative, less conservative, criteria and 'risk it'. Therefore, it is recommended that future studies should be carried out to determine whether this suggested effect actually exists, and, if it does, to uncover drivers likely to be subjected to such criteria shifts, and the circumstances under which they may alter such criteria.

10.2.4 Cross-Traffic Accidents

Only a small number of cross-traffic conflicts were observed during the first study. In a similar way, details of few left-turn accidents were recorded in the questionnaire study, and for both studies these two categories of incident were treated as synonymous. Indeed, it was concluded that both forms of incident must generally result from poor detection of other vehicles, and this issue was dealt with in the previous section. As Rumar (1990) suggests, a driver searching for on-coming vehicles is operating at Rasmussen's (1983) rule-based level of behaviour, rather than skill-based, and the driver is therefore:

"...more vulnerable to errors, and due to the speeds and the masses involved it is very difficult to compensate for an error once it begins to occur. Errors are thus more probable and difficult to overcome." (Rumar, 1990, p. 1284).

In the previous section, the possibility that left-turn incidents may often result from poor application of gap acceptance criteria was discussed and it is suggested that the same may be true of the cross-traffic class. However, it is was also noted that many may result from a failure to initially detect other vehicles. Certainly, the police records are filled with statements along the lines of 'I just did not see the other vehicle'. Unfortunately, there does not appear to have been any research carried out to investigate this possibility, although a study conducted by McKenna, Duncan and Brown (1985) did investigate the relationship between aspects of driving and performance on the Embedded Figures Test (EFT), amongst several others. No significant correlations between performance on this test, nor on either a dichotic listening task nor the 'Stroop Effect', and accident rates were found, although a very small significant positive correlation ($r=0.18$, $r^2=0.03$) between the EFT and PSV training success was found. The researchers concluded that this test did not measure a universal ability for the drivers to resist distraction.

Despite this, Rumar (op. Sid.) has listed many ways in which vehicle visibility could be improved upon, such as use of vehicle colouring and lights. However, it should be noted that there is no evidence to suggest that some drivers fail to perceive other vehicles because these other vehicles lack suitable visibility, and it may be more a function of the perceivers' expectations (ie. schemata). Once again, it should be stressed that this is purely speculation, and that much research would need to be performed before firm conclusions may be drawn.

10.2.5 Other Accident Types

The current study has aimed to investigate the major forms of accidents at junctions, and it is argued that it has been able to provide much useful information concerning these accidents and possible directions for further research. However, is not suggested that this study provides a comprehensive guide to all of the major accident forms at junctions. Perhaps the most common category that was not included was the 'right turn', which bears some similarities to the 'left-turn' and 'cross-traffic' accident types. No examples of an accident resulting from this type of manoeuvre were found in the accident records of the four junctions investigated in Study 1, partly because, by definition, this form of manoeuvre is not possible at roundabouts. However, a small number (2) of conflicts of this nature were noted at Site 4, although this was an insufficient number upon which to perform analyses. Similarly, only a couple of examples of right-turn accidents were obtained in the questionnaire sample, and it is therefore suggested that, whilst this form of accident obviously warrants some attention, it appears to a relatively infrequent type. Therefore it is recommended that the other accidents types covered by this research should provide the main areas of study.

Of course, there are many other accidents forms, such as loss of control through skidding, hitting a pedestrian or collisions through impaired functioning (eg. due to excessive alcohol intake), but it is argued that the more common vehicle-vehicle accident types were covered by the study.

10.3: IMPLICATIONS OF THE MAIN FINDINGS OF THE CURRENT RESEARCH FOR THE LITERATURE

10.3.1 Implications for the Study of Driver Errors

The second phase of the research attempted to uncover factors related to differential accident involvement, and therefore the extent to which the findings may be able to contribute to the study of driver errors is limited. Although it would be interesting, from a GEMS (Generic Error Modelling System, devised by Reason, 1987 - see Section 1.5.2) perspective, to determine which mode of activity (ie. skill, rule or knowledge-based) a driver was operating in at the time of the accident, it is not possible to elicit this level of information from the questionnaire used. Indeed, it would require a far more detailed set of questions to achieve this and it is suggested that it may be more profitable to study driver errors by conducting one-to-one interviews, a technique recently adopted by Taylor (1990).

However, the discriminatory power of the self-descriptor metavariables, and to a lesser extent the perceived risk metavariables, in several of the analyses described in Chapter 8 suggests that it would be worthwhile investigating what relationship, if any, these factors have with error causation. More specifically, it would be useful to determine if certain traits, such as self-centredness or inaccurate perception of the chances of poor junction approaching behaviours resulting in an accident for example, cause their possessors to be predisposed to making slips, lapses or mistakes or to be involved in violations. In some ways, these traits can be seen as the latent 'general failure types', an intrinsic part of the Tripod model (Reason et al., 1988). In fact, a recent study by Reason, Manstead, Stradling, Baxter and Campbell (1990) has shown that, when respondents were asked to state their level of participation in a whole range behaviours, three main categories emerged: violations; dangerous errors; and harmless lapses. The implications are that the underlying psychological processes may be different for errors and violations, and this was further supported by differences related to the age and sex of the respondent.

10.3.2 Implications for the Use of Risk Models in Driver Behaviour Research

It was previously noted in Section 10.2.1 that the relative success of the perceived risk items in discriminating between sub-groups of accident-involved drivers implies that some drivers (eg. those culpable for an accident) may have, in Summala and Näätänen's (1988) terms, poorly developed 'fear monitors' (or 'subjective risk monitor' in their initial model, Näätänen and Summala, 1976). The suggested method of overcoming this is to ensure that the subjective risk of each driving situation as closely matches the objective risks of those situations as possible.

In a similar manner, it is suggested that the same implications apply to Bötticher and van der Molen's (1985) hierarchical risk model. In this case, the inadequate model of the driving environment lies in the 'internal representation', in which the accident expectations (ie. the probability of an action resulting in a collision) concerned with particular manoeuvres may be distorted. An example of this from the current study would be the belief that careless junction approach practices are less likely to result in an accident held by accident-culpable drivers when compared with accident 'victims'. However, Bötticher and van der Molen's model includes a motivational component, and it may be that some drivers also possess distorted 'safety motivations' (ie. the perceived consequences of an outcome). In a similar way, the model suggests that such inadequacies would be best remedied by supplying drivers with accurate information concerning the driving environment. Unfortunately, there is no evidence to suggest that this would alter the way in which these people actually drive or perceive the driving of themselves and of others.

Concerning Fuller's 'Threat Avoidance Model' (TAM), it is difficult to interpret the implications of the current findings without more detailed knowledge of the accidents. In particular, it would have been useful to determine to what extent, and under which circumstances, some drivers employ anticipatory avoidance responses. However, as with the two previous models discussed, it is argued that this study has been able to demonstrate that some deficiencies in drivers' representations of the relationship between various conditioned stimuli (CS_1) and the relevant precursor factors (CS_2) may be present. As Michon (1989) points out (see Section 1.6.4.3) though, it is likely that the circumstances involved in the majority of accidents are too complicated to be explained by simple threat-avoidance reactions.

It can be argued that the current study has only been able to confirm that problems may reside in structures such as the 'fear monitor' or 'internal representation', but little can be said concerning the ways in which such deficiencies can be overcome. The implication is that accurate 'fear monitors' and 'internal representations' should be formed at an early stage, but this offers no help to the experienced driver as there is no suggestion as to how inappropriate versions may be 'corrected'.

Given the conclusions noted previously (Section 1.6.5.2), that the central components of each of these theories is essentially dealing with the same concept, also known as schemata, the implications for this will be discussed in the following section.

10.3.3 Implications for the Use of Schema in Driver Behaviour Research

It has already been noted that, according to Norman's (1981) Activation-Trigger-Schema framework (see Section 1.7.2.1), there are three main forms of error. One of these error forms results from not reaching the necessary activation level to trigger a schema, and this must be a consequence of either inappropriate perception of the situation, or an inappropriate activation level. The former certainly ties in with the conclusions drawn about left-turn (ie. gap acceptance criteria) and cross-traffic (inappropriate following distances) accidents discussed in the previous section (10.2), whilst, being an intrinsic part of the schema, the activation level must have been set as a direct result of previous experience.

Hogarth's (1987) Conceptual Model of Judgement (see Section 1.7.2.2) suggests that bias, and therefore errors, can occur at several stages of activity. The first of these concerns bias at the acquisition of information stage, and this is where an error by a driver in pulling out at a junction and colliding with a vehicle s/he did not perceive would be made. Hogarth's fourth source of bias, in the feedback stages of performance, also has implications for the research. The example that was cited was the confusion between chance occurrences and causal relationships, and attributional errors may result. This bias was clearly demonstrated in the current study by the tendency for some drivers felt by the independent raters to be responsible for their described accident to attribute accident culpability to other parties involved.

In Section 1.7.3, it was felt that the study of driving schemata would enable sources of bias to be highlighted and corrected. However, it has also been noted that schema must, by necessity, contain information concerning perceptual abilities and judgemental criteria and it is hard to understand how existing schema that have been shown to be inappropriate may be altered. It is unlikely that drivers who may be prone to making poor judgemental decisions can be taught to make 'better' judgements, and it may be more appropriate to attempt to instill a more cautious, or defensive, driving style in these drivers.

Concern was expressed in Section 1.8.2 that, by definition, schemata are highly complex, inter-related phenomena with many components, and that it will almost certainly be impossible to fully encapsulate any single schema due to that highly complex and probably largely subconscious nature, supporting Baddeley's (1976) concern that schemata must be largely untestable and therefore not useful. However, it was hoped that the current study would be able to uncover some more general aspects of schemata with relation to junction accidents, and it is argued that this was achieved to a certain extent. For example, it was found that drivers responsible for accidents at junctions were more likely than accident 'victims' to feel that careless and egocentric junction approach styles would result in an accident. If it is presumed that this is a manifestation of the junction approach schema held by these drivers, it might be expected that these people would drive in a manner that reflected this belief and therefore it should come as no surprise to find that they have been involved in an accident.

Even so, it is suggested that this does not really reveal much about *why* such beliefs should put the 'culpable' drivers at greater risk of accident-causation as implied, simply presuming that it must reflect their own junction approach style. If this were so, it might be expected that drivers scoring more highly on this metavariable would be more likely to be involved in an accident on the approach to a junction rather than at another location. Further analyses would need to be performed to ascertain whether this is so.

It must be concluded that, whilst it is likely that some aspects of junction schemata may be determined by the method adopted in this study, they are likely to be too complex to investigate fully in this manner, and perhaps by any other method too. However, it is argued that schemata provide a useful framework in which to operate, and even if a schema can never be fully 'mapped out', studying aspects of 'sub-schemata' may prove to be a profitable exercise.

The primary purpose of this research was to point to ways in which training may be able to improve driver behaviour, and therefore the final main section of this chapter will discuss the implications of the findings of the current study for driver training.

10.4: IMPLICATIONS FOR DRIVER TRAINING

One of the main analyses concerning training described in Chapter 8 was that which found that drivers primarily trained by a qualified instructor were more likely to respond to self-descriptor and reported behaviour items in a similar fashion to drivers found to be accident-liable. Although the accident rates for these drivers were not found to differ from those trained by other methods when experience was accounted for, this has clear repercussions for driver training. Additionally, the professionally taught drivers were found to be less likely to implement an accident-avoidance measure when confronted with an accident situation. This was taken (see Section 9.4.1) to mean that these drivers are less likely to have a suitable range of potential avoidance techniques upon which to draw when the need arises.

Such factors appear to confirm the concern expressed by Brown, Groeger and Biehl (1987) (see Section 1.4.2) that the current methods of novice training are not providing drivers with sufficient ability to cope with the demands of the traffic system. Certainly, it is implied from the characteristics supposedly displayed by these drivers that tuition from a qualified instructor 'creates' drivers who are inconsiderate to other road users. However, there remains the possibility that generally inconsiderate people choose to learn with a professional school rather than a friend or relative. Alternatively, this could be a consequence of the finding that these characteristics tend to be more prevalent in younger drivers and that younger drivers are more likely to learn with a professional school. Once more, a longitudinal study would need to be performed to ascertain whether or not this is the case.

Assuming for a moment that this is a genuine phenomenon, the possible reasons for its' development should be discussed. One of the problems probably stems from the fact that professional courses tend to concentrate primarily upon development of the motor skills essential to learning to drive and the traffic laws. This focus upon skill and rule-based modes of operation, in Rasmussen's (1983) terms, necessarily implies that such aspects as procedural knowledge, important for the development of appropriate schemata, are neglected. As Michon (1988b) points out, the knowledge imparted during tuition has little to offer concerning this procedural knowledge, and it could be that:

"...the instructor's representation of the driving task is fundamentally different from what the student is actually being taught." (Michon, 1988b, p. 509).

The implication is that learner drivers should have access to more knowledge-based modes of operation. However, by definition, these are mainly derived from direct experience, and it is difficult to envisage how this information could be put across to trainee drivers. As Fuller (1988) states, what inexperienced drivers most lack is exposure to the contingencies of the driving situation. But learner drivers cannot simply be 'given' the experience that increased exposure brings. Nevertheless, the evidence suggests that learner drivers require more complex information concerning the social norms of the road user system, however this may be imparted.

Brown, Groeger and Biehl (op. cit.) suggest that, as feedback is clearly essential to any learning process, it may be beneficial for instructors to train their pupils to be more receptive to the types of non-verbal feedback upon which they must rely when driving unsupervised. In other words, people should be taught to monitor their own driving through using feedback, although Michon (op. cit.) feels that the fact that drivers are probably unaware of the underlying processes governing behaviour will render this ineffective. However, it is argued that it may be possible to somehow impart information concerning these underlying processes and accompanying potential sources of bias to drivers. This extra form of tuition need not be given to all trainee drivers and it may be more practical to 'target' drivers who show tendencies towards displaying certain accident-implicating characteristics (ie. those who would describe themselves as more self-centred and ill-mannered).

Further clues as to how to improve driver training were uncovered from the analyses investigating differences between those respondents who had received some advanced tuition and those who had not (see Section 8.8). Advanced training was found to have a positive effect upon accident rates, although exposure factors rendered this effect non-significant. Despite the possibility of a self-selecting bias (see Section 9.7.2), evidence was found to suggest that those drivers with advanced training may display opposite tendencies to those expressed by accident-culpable drivers (such as poor attendance to vehicles in front and impatience). Indeed, these drivers were generally found to report more attentive and considerate traits. These factors were not implicated in differential accident-involvement, a finding which appears to support the lack of difference between the accident rates of those drivers with and those without advanced training.

Receipt of advanced training was also found to be a good indicator of drivers who believed that their reported accident had been preventable. It was hypothesized in Section 9.5.2 that this may be due to the possibility that advanced trained drivers are more aware of the range of possible actions even if they are not more able to implement them. Despite this latter assertion, it is clearly preferable for a driver to be more fully aware of the possibilities for action in each situation that they encounter and the evidence presented here suggests that those drivers who have received some form of post-test training are more likely to have this increased awareness.

This certainly bodes well for advanced training methods, and, rather than make advanced training compulsory, it is felt that it would be more productive to isolate the crucial elements from advanced training methods and transpose these to the tuition given to learner drivers.

Section 1.4.3 mentioned the study performed by Fazakerley et al. which demonstrated that participants in a 'Better Driving' course showed an improved level of knowledge and performance, suggesting that this form of tuition is more able to pass on the kind of procedural, knowledge-based information previously discussed. Certainly, one aspect of these advanced forms of tuition is that they appear to encourage drivers to perform the kind of self-monitoring advised by Brown et al. (op. cit.) and to be more aware of the entire driving sub-system. Again, further research would need to be conducted before the crucial elements that make advanced training desirable can be isolated and this would preferably be of a long-term nature so that such potentially confounding effects as the self-selection bias can be overcome.

10.5: RECOMMENDATIONS FOR FURTHER RESEARCH

The utility of observational data has been demonstrated throughout this research, but it is argued that refinements could be made to the technique. For example, it was felt that the junctions selected for study could not represent the full range of junction-types in the road network. It is therefore suggested that a similar observation study should be performed on an additional number of different junctions, such as a busy urban T-junction, before a truly comprehensive qualitative and quantitative guide to driving at junctions can be arrived at. Additionally, it is recommended that observations are made over a number of days and at a variety of additional time periods to ensure that the sample obtained is fully representative of the driving population.

The transformation of Site 4 from a complex T-junction to a roundabout provided an ideal opportunity to perform a 'before' and 'after' study and it is suggested that the effectiveness of the changes in counteracting undesirable driving practices could be assessed by repeating the observation of the junction.

Conducting further observations of driving behaviour at junctions would also enable a wider range of phenomenon to be analysed in greater depth. For example, Study 1 was unable to offer much information concerning drivers' braking activity and it is suggested that future research should aim to gather a more comprehensive guide to all behaviours. It may be remembered (see Section 5.4.4) that such recording of braking activity was not possible due to the limited field of vision of the video camera and it is suggested that, if practical, several cameras focusing upon different areas of the approach to the junction and the junction itself could be synchronized and used simultaneously.

Several aspects of the questionnaire survey also highlighted potential areas for future research. A primary concern of the accident information collected by the questionnaire was the lack of sufficient details provided by many of the respondents, and this led to the conclusion that some of the assignments of accident culpability may have been erroneous. Indeed, it is argued that a higher level of detail must be obtained if accurate error analyses are to performed. The most effective way to combat this would be to gather information from as many relevant sources as possible, including conducting personal interviews with all involved parties and obtaining access to reports made by insurance companies and the police, if involved. Of course, the practical implications of this technique may render its' use impossible, but it is argued that future studies should make attempts to supplement the types of accident information gathered here with that derived from open-ended interviews with the involvees wherever possible.

An additional problem with the questionnaire concerned the metavariables produced from the factor analyses performed on the item sets. It was suggested in Section 9.3.6 that the reliable metavariables did not cover the full range of junction negotiation behaviours and it was recommended that future studies should perform more extensive piloting exercises to ensure that this wider range of reliable metavariables are available for analyses.

In Section 10.1 it was noted that, by nature, the information gathered by questionnaire studies is retrospective, and the researcher can never arrive at any conclusions concerning accident causality. It was therefore suggested that it would be useful to perform a longitudinal investigation of accident causation, and the factors associated with it, by performing a multi-stage survey on a large sample of drivers. In this way, it could be determined whether the opinions and beliefs of drivers change as a result of accident involvement, or whether these remain stable over time. It is also possible that such a study could be employed to investigate the possibility of changing gap acceptance criteria, as noted in Section 10.2.3.

Finally, it was found that drivers who are primarily taught by a professional instructor reported several accident-implicated traits, whilst those who had been in receipt of some form of advanced training reported some opposing traits. It was therefore felt (see Section 10.4) that it would be of value to isolate the elements of the advanced training courses that contribute to this possible effect and it is recommended that a thorough investigation of advanced tuition should be conducted.

10.6: CONCLUSIONS

1) The research technique of using both objective and subjective data collection methods was able to provide considerable useful information concerning accidents at junctions.

2) Approximately 7% of all vehicles at the four junctions observed were involved in some form of near-miss incident.

3) Over a third (33.7%) of drivers were found to follow the preceding vehicle with a gap time of under 3 seconds and just over a fifth (21.1%) adopted following times under 2 seconds.

4) 23% of drivers gave an incorrect or no direction indication, with left-turns found to be particularly poorly indicated.

5) Traffic density was found to be the best predictor of a vehicle's approach speed in the final sector of the approach to a junction.

6) The relationship between traffic conflicts and accidents, when traffic flow was controlled for, was found to ambiguous. Some junctions displayed strong positive relations whilst one displayed a strong negative relationship. It was concluded that the situation at each junction is unique, and therefore that each should be treated in isolation.

7) Prediction of involvement in traffic conflicts from observational data was extremely accurate. The presence of a queue at the 'Give Way' line was found to be the best predictor of involvement in 'rear-end shunt' conflicts, whilst the presence of other vehicles on the junction and acceptance of a 'pull-out' criteria of under 5.4 seconds were found to be the most effective predictors of involvement in left-turn/cross-traffic conflicts.

8) Details of 383 accidents were reported by the respondents to the questionnaire survey, with the rear-end shunt being the most common form (18.8%), and T-junctions being the most common location (35.0%).

9) When assignments of accident culpability were made, 32.0% denied culpability in cases where a group of independent raters felt they were culpable.

10) Exposure and sex were both found to be excellent predictors of accident-involvement, as was the respondents' tendency to describe their own driving as self-centred and ill-mannered.

11) In contrast, accident-culpable drivers and accident victims were found to be similar in terms of exposure and score on the self-centred/ill-mannered metavariable, but differed on some of the more attitudinal items. The culpable drivers were found to be more likely to report being worse attenders to vehicles in front, be more impatient and to perceive careless junction approach styles as being more likely to result in an accident.

12) Whether a culpable accident-involved driver admitted or denied culpability was found to be largely dependent upon age and scores on one of the self-descriptor metavariables. The 'deniers' describing themselves as being less self-centred/ ill-mannered and also being generally younger at the time of the accident.

13) The main difference between those drivers who reported implementing some form of accident-avoidance measure and those who did not was found to be that the latter were more likely to have received most of their pre-test training from a professional instructor. It was hypothesized that this provided some evidence for suggesting that such methods of novice training do not adequately prepare newly-qualified drivers for the demands of the road environment.

14) The extent to which accident-involved drivers felt their accident was preventable was investigated. Those who felt there was something they could have done were found to describe themselves as being more negligent and were also more likely to have embarked upon some form of advanced training course. It was concluded that such advanced training may serve to ensure that the participants are more aware of the possibilities for accident prevention.

15) Drivers involved in rear-end shunt collisions were more likely to feel that they were culpable than those involved in left-turn or cross-traffic accidents.

16) Scores on the self-descriptive metavariable measuring drivers' degree of self-centred/ill-mannered driving was found to be most effectively predicted by age and it was concluded that this type of driving may be more a function of youth rather than a lack of experience.

17) Drivers trained by a friend or relative reported a higher level of accident-involvement, although this was accompanied by a higher mileage, and these drivers were found to have the safest record when mileage was controlled for.

18) Drivers who had received some form of advanced tuition were found to have better miles-per-accident records than those who had not received any training, although the best combination of training was found to be novice training from a qualified instructor followed by advanced training.

19) Drivers trained by a qualified instructor were found to respond to several items in similar ways to accident-liable drivers such as reporting themselves to be more self-centred and ill-mannered.

20) Drivers who had received advanced tuition were found to report in ways that displayed more considerate and attentive traits such as being more likely to attend to vulnerable road users and more likely to be better attenders to vehicles in front on the approaches to junctions.

21) Several recommendations for further research were discussed, most notably the need for longitudinal studies to counter the retrospective nature of this research. The main advantage of this approach would be to enable causal relationships between accident-involvement and factors found to be associated with accident-involvement to be established.

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